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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXX.—*Recent Changes in the Elevation of Land and Sea in the Vicinity of New York City;* by GEORGE W. TUTTLE.

THE late Professor George H. Cook, long identified with the Geological Survey of New Jersey, read an important paper at the Montreal meeting of the American Association for the Advancement of Science, August 13th, 1857, "On the subsidence of the land on the seacoast of New Jersey and Long Island,"* in which he stated that "an attentive examination of these facts has led me to the conclusion that a gradual subsidence of the land is now in progress throughout the whole length of New Jersey and Long Island, and from information derived from others I am inclined to think that this subsidence may extend along a considerable portion of the Atlantic coast of the United States."

The evidence on which Professor Cook based this conclusion was mainly of a geologic nature, and consisted of, 1st, submerged forests and buried timber found in the marshes and along the coast below tide level; 2d, numerous Indian shell heaps which have been found below tide level; 3d, the extension of the marsh on the upland, verified by many old residents, and by the dying out of cedar trees on the margin; 4th, less fall of water at any stage of the tide available to operate the waterwheels of mills on tidal streams near the sea.

It was the opinion of a number of mill operators, that within their memory the loss of head available to operate their wheels was of such an amount as would denote the sinking of the land at the rate of two feet per century. Besides, sluices in banks protecting meadow land, built about 150 years ago, were found three feet below tide level and useless for their intended purpose.

Professor Cook's estimate of the amount of subsidence of the

* This Journal, 2d Series, xxiv, 1857, p. 341.

land, which has been quoted by many authorities, rests on the above evidence, and is manifestly open to doubt and uncertainty, as he recognized when he wrote in his 1885 report, that "we find conclusive evidence of a general subsidence of the coast, or rise of water level to an extent of from ten to twenty feet within a short period of geologic time, but at a rate which is not quite definitely established." Professor Cook furthermore stated in his report of the Geology of New Jersey in 1868, that "this movement is one of a series which has occurred on our coast by which the line of water level has been alternately elevated and depressed, the whole range being confined within twenty feet."

Others have since frequently expressed the same ideas, but as they probably made use to a large extent of Professor Cook's opinions and evidence, it will be needless to quote them.

The self-registering tide gauge had only recently been made use of when Professor Cook read his paper, and tidal observations could not be obtained to determine the rate of subsidence, but since that date long series of tidal observations have become available, and it is proposed to develop in this paper what such observations in New York Harbor can tell as to the relative changes in the elevation of earth and sea in the vicinity.

The tidal observations at New York, which are of importance, start from the year 1853, when a self-registering tide gauge was put in operation by the Coast Survey at Governor's Island, and maintained up to and including the year 1879, when the series terminated. We also have the records of a self-registering gauge maintained by the Coast and Geodetic Survey during the years 1876–92, at Sandy Hook, N. J., records of self-registering gauges of the Department of Docks and Ferries from 1888–1903, at Pier A, West 57th St., and from 1894–1903 at East 24th st., in New York City, besides the record from a self-registering tide gauge of the Coast and Geodetic Survey at Fort Hamilton, for the years 1893–1902.*

The observations at Governor's Island were all referred to B. M.,† which was established about the year 1853 by the Coast Survey and is still in existence. Levels were run from this bench mark to other benches, in 1875 and again in 1886. The differences found at those times were checked in 1898 and 1900 and found correct, so that we may be confident that since 1875 B. M., has not settled or been otherwise disturbed.

The datum plane used in this paper is mean low water—

* The writer is indebted to the U. S. Coast and Geodetic Survey and to the Department of Docks and Ferries, New York City, for tidal data not hitherto published.

† For description see C. and G. S. Report 1887, app. 14, p. 293.
" " 1899, app. 8, p. 555.

M. L. W.—at the Battery as used by the Department of Docks and Ferries which is known as Battery datum, and is 2·186 feet below the datum plane of the Coast and Geodetic Survey in their levelling operations in the vicinity of New York City.*

The elevation of B. M.$_1$ from the above Coast and Geodetic Survey levels is 14·203 feet, and from ordinary levels run directly from the Battery to Governor's Island the elevation 14·160 was obtained. We shall adopt the former value in the succeeding work.

The following is the record of the observations at Governor's Island for each year.

Year.	Half tide level above zero of staff.	Half tide level above Battery datum.	
1846	8·32 ft.	----	
1847	10·31	----	
1848	13·12	----	
1849	12·92	----	
1850	14·16	----	
1851	12·20	----	
1852	10·51	----	
1853	5·30	1·920 ft.	Probable elevations
1854	5·07	1·690	
1855	5·32	1·940	
1856	7·507	1·778	
1857	7·640	1·911	
1858	7·591	1·862	
1859	7·616	1·887	
1860	7·575	1·846	
1861	6·580	1·921	
1862	6·494	1·835	
1863	6·498	1·839	
1864	6·570	1·911	
1865	6·476	1·817	
1866	6·468	1·809	
1867	6·615	1·956	
1868	6·557	1·898	
1869	6·435	1·776	
1870	4·620	1·961	
1871	4·472	1·813	
1872	4·468	1·809	
1873	4·516	1·857	
1874	4·358	1·699	
1875	4·40	1·741	
1876	4·46	1·801	
1877	4·56	1·901	
1878	4·68	2·021	
1879	4·64	1·981	

* See appendix 14, Report of Coast and Geodetic Survey, 1887.

The above series of tidal observations from 1870–79 were carefully examined for use in determining the mean sea level—M. S. L.—in New York harbor* and these values resulted:

Year.	Mean sea level above zero of staff.	Mean sea level above Battery datum.
1870	4·692 ft.	2·033 ft.
1871	4·545	1·886
1872	4·533	1·874
1873	4·612	1·953
1874	4·410	1·751
1875	4·505	1·846
1876	4·540	1·881
1877	4·630	1·971
1878	4·751	2·092
1879	4·688	2·029

The zero of the tide staff at Governor's Island was found by levelling to be 16·899 ft. below B. M.$_1$ in 1871–2 and 16·826 in 1875. Consequently the mean of these two values, 16·862 ft., has been adopted as the correct value for the series of observations 1870–79.

The elevations of half tide level†—H. T. L.—from 1853 to 1869 are subject to considerable uncertainty owing to changes in the elevation of the zero of the tide staff, of which no record appears to have been made. Such changes must have taken place in 1856, 1861, and 1870. In 1853 the zero of the tide staff was recorded as 17·00 ft. below B. M.$_1$, but this location does not harmonize with the succeeding observations and there is much evidence to contradict it.

We determine the probable elevations of H. T. L. at Governor's Island for the years 1861–69, by making the average H. T. L. for the four years 1866, '67, '68, and '69 have the same elevation as the average for the four years 1870, '71, '72, and '73: the elevations of H. T. L. for the years 1856–60 are fixed by giving the average of the observations for 1857, '58, '59, and '60, the same elevation as those of 1861, '62, '63, and '64; and finally we make the average H. T. L. for the three years 1853–55 the same as the average of the three years 1856–58. Very nearly the same values are arrived at if we start with the elevation 14·51 ft. of B. M.$_1$ above M. L. W. given in the Coast Survey Report for 1853. We also observe that the series of 1861–1869 shows no tendency toward increased elevation with the time, and for that reason they seem to confirm our location of the 1853–55 observations.

These elevations are still further shown to be the most probable ones, from the fact that in 1879 the elevation of B. M.$_1$

* Coast and Geodetic Survey Report for 1899, p. 404.

† Which is the average of high and low tides.

was given as 14·6 ft. above M. L. W. "from the observations of 1853 verified in 1873"; and that the observations of H. T. L. at Boston from 1853–5 and 1870–3 have substantially the same relative elevations and yearly fluctuations.

From October 2d to 30th, 1886, a series of comparative tidal observations were carried out at Governor's Island and Sandy Hook, and the resulting M. S. L. corrected for annual inequality above zero of staff at Governor's Island was 4·200 ft., with zero of staff at that time 16·43 ft. below B. M.$_1$, making M. S. L. 1·973 ft. above Battery datum.

We next have the tidal observations at Sandy Hook, which are as follows:

Year.	M. S. L. and H. T. L. above Sandy Hook datum.		Equivalent H. T. L. at Governor's Island above Battery datum.
1876	6·74		1·774
1877	6·90		1·934
1878	7·06	M. S. L. from hourly	2·094
1879	6·87	heights	1·904
1880	6·84		1·874
1881	6·89		1·924
1882	6·90	H. T. L. from high	1·934
1883	7·02	and low waters	2·054
1884	(7·17)	(values in parenthe-	2·204
1885	(6·82)	sis partly estimated)	1·854
1886	(6·90)		1·934
1887	6·91		1·944
1888	7·00		2·034
1889	7·13	M. S. L. from hourly	2·164
1890	7·05	heights	2·084
1891	7·09		2·124
1892	7·05		2·084

The observations made at Sandy Hook were referred to a plane 17·63 below B. M. T.,* and are reduced to Battery datum by means of the simultaneous observations for the four years 1876–1879 at Governor's Island and Sandy Hook.

While spirit levels have been taken between Sandy Hook and Governor's Island, yet, owing to the considerable distance of the run, they are probably in error more than levels derived from the simultaneous tidal observations.

The levels derived from the four years of tidal observations agree almost precisely with the levels obtained from the simultaneous tidal observations in October, 1886, and are more suitable to reduce the Sandy Hook observations to simultaneous ones at Governor's Island than the spirit levels. From the spirit levels of 1887 as revised in 1899, the elevation of B. M.

* Described in C. and G. S. Report for 1887, appendix 14.
" " " 1899, page 472.

Governor's Island, above B. M. T. Sandy Hook was 1·361 ft., while from the simultaneous tidal observations of October, 1886, the difference was 1·468 ft., and from the tidal observations of 1876–9, 1·472 ft. This latter difference has been adopted in the reduction.

The observations at Sandy Hook have to be reduced to the equivalent values of half tide level at Governor's Island, which for the ten years 1870–79 was ·067 ft. lower than mean sea level, and consequently the elevations have been corrected by this amount in the column "Equivalent H. T. L. at Governor's Island above Battery datum."

The tidal records at Governor's Island from 1870–79 are particularly important in this investigation, and while the observations appear to be satisfactory, the frequent change of staffs make it desirable to have an independent check on their accuracy which we have in the observations at Sandy Hook in 1876–79, taken in connection with the levels obtained from the simultaneous tidal observations in October, 1886.

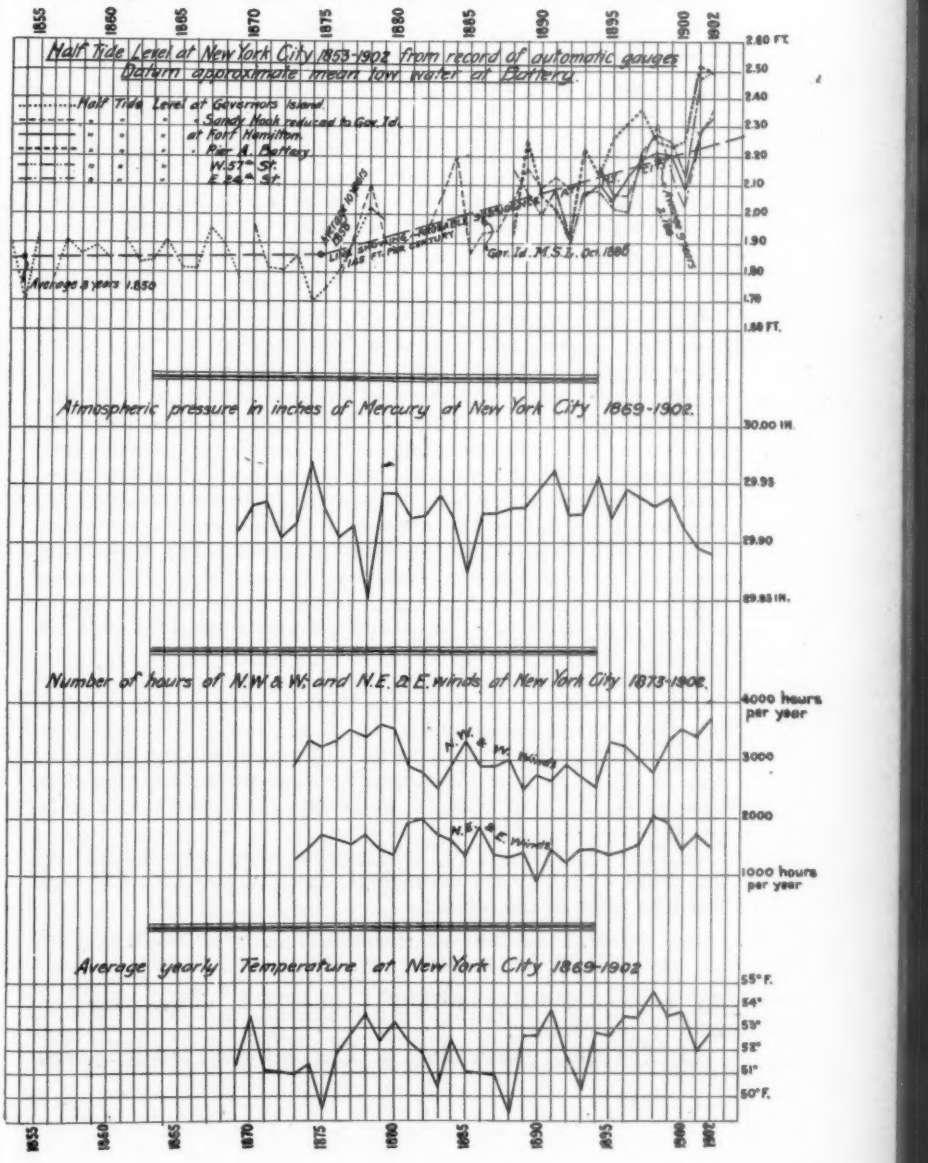
We next have a series of tidal observations at Fort Hamilton, N. Y., from 1893–1902, as follows:

Year.	H. T. L. above zero of staff.	H. T. L. above Battery datum.
1893	5·815 ft.	2·067 ft.
1894	5·885	2·137
1895	5·785	2·037
1896	5·875	2·127
1897	5·945	2·197
1898	5·960	2·212
1899	5·955	2·207
1900	5·820	2·072
1901	6·030	2·282
1902	6·085	2·337

The zero of the gauge at Fort Hamilton was 42·194 ft. below B. M. L. (destroyed in 1901), and 17·951 ft. below B. M., at Governor's Island, according to the Coast and Geodetic Survey levels of 1887. Two independent determinations of this difference in elevation have since been made, one in 1898 of 17·971 ft., and in 1900 of 18·019 ft. The 1887 value has been adopted, however, in the reduction of the staff readings to Battery datum.

Besides the above observations of the Coast and Geodetic Survey, we have the following tidal records of the Department of Docks and Ferries, all referred to Battery datum.

Diagram showing the yearly averages of Half Tide Level at New York City and the corresponding yearly averages of the principal meteorological phenomena.



	Half tide level above Battery datum.		
	Pier A.	West 57th St.	East 24th St.
1889	2·273 ft.	2·079 ft.	----
1890	2·063	1·990	----
1891	2·012	2·082	----
1892	1·910	1·902	----
1893	2·232	2·075	----
1894	2·133	2·075	2·164 ft.
1895	2·265	2·018	2·067
1896	2·314	2·003	2·053
1897	2·359	2·212	2·173
1898	2·258	2·278	2·301
1899	2·230	2·245	2·127
1900	2·250	2·127	2·012
1901	2·514	2·461	2·274
1902	2·490	2·492	2·361
1903	2·343	2·433	2·295

The yearly averages of half tide level at New York which have been given, are plotted in the diagram on page 339. They show a continual oscillation, having an amplitude of nearly 0·3 ft., about an average value which since 1875 has uniformly increased. These oscillations when considered in relation to the accompanying meteorological phenomena, also represented in the diagram, are seen to be mainly due to atmospheric pressure and winds. They are more or less perfectly eliminated by taking the average for five or more years, and when thus eliminated the observations appear to show that mean sea level remained nearly stationary from 1853 to 1875, since which time it has been rising relatively to the land by about 1·45 ft. per century. The rate of change since 1875 may be obtained in the following different ways.

(1) From ten years' observations at Governor's Island, 1870–79, the elevation of M. S. L. was 1·932 ft., and at Fort Hamilton the average elevation of H. T. L. from 1893–1902 was 2·165 ft.; allowing 0·03 ft. as the difference between M. S. L. and H. T. L. at Fort Hamilton, we have an increase in elevation of H. T. L. of 0·26 ft. in twenty-three years, or 1·1 ft. per century.

(2) The observations at Fort Hamilton alone, give the following result by taking the average H. T. L. of the first five and last five years of the series:

H. T. L. 1893–97 elevation..... 2·108 ft.
H. T. L. 1898–1902 " ..... 2·223

An average elevation of H. T. L. of ·115 ft. in five years, or 2·30 ft. per century.

(3) The tidal observations at Pier A for the last ten years,

1893–1902, give 2·304 ft. as the elevation of H. T. L. at Pier A, while H. T. L. at Governor's Island 1870–79 was 1·858 ft., an increase in the elevation of H. T. L. of ·446 ft. in twenty-three years, or 1·94 ft. per century.

(4) The observations at Governor's Island 1870–79 give

Elevation of M. S. L. 1870–74	1·899 ft.
Elevation of M. S. L. 1875–79	1·964

An increased elevation in M. S. L. of 0·065 ft. in five years, or 1·30 feet per century.

(5) The observations at Sandy Hook for the seventeen years 1876–1892 give:

Elevation of M. S. L. 1876–1881	6·883 ft.
Elevation of M. S. L. 1887–1892	7·038

An increased elevation in M. S. L. of 0·155 ft. in eleven years, or 1·41 ft. per century.

(6) The observations for the fourteen years 1889–1902 at Pier A, when taken by themselves, give:

Elevation of H. T. L. 1889–1895	2·127 ft.
Elevation of H. T. L. 1896–1902	2·345

An increased elevation in H. T. L. of 0·218 ft. in seven years, or 3·1 ft. per century.

(7) The average of the observations of H. T. L. for the ten years 1870–1879 at Governor's Island, compared with all the above mentioned observations at New York for the nine years 1894–1902, shows that H. T. L. has risen ·326 ft. in twenty-two and one-half years, or at the rate of 1·45 feet per century.

(8) The Department of Docks and Ferries of New York City found it necessary in 1898 to raise their plane of mean low water (to which soundings are reduced) 0·24 ft. above that in use since 1872; and the U. S. Engineers in 1900 raised their plane of mean low water 0·32 ft. above that used in 1872.

On account of the many disturbances to which tidal observations are subject, the frequent change of tide staffs in some cases, and the settlement of bench marks, it is necessary to use considerable caution in the interpretation of the observations, and all possible checks should be used. Only when independent determinations show a reasonable agreement, can we feel sure of the result arrived at.

Besides the errors which may occur in the measurement of the elevation of mean sea level, it is subject to changes from many causes, among which may be mentioned changes in atmospheric pressure, winds, temperature, various tidal components having periodicities ranging from six hours to nineteen years, river outflow, evaporation, changes in ocean currents, melting of polar snow and ice, changes in salinity,

detritus carried into the sea by rivers, and the wearing away of shores, as well as changes in the position of the earth's axis and speed of rotation.

High and low waters only were measured in most of the observations, and consequently H. T. L., which is the mean of the above quantities, has been given in the tables, except in a few instances.

In general M. S. L. obtained from hourly ordinates, which determines a level surface, differs from H. T. L. to a small extent, depending in amount on the shape of the tide wave. In deep water this difference is usually quite small, but in shallow water, or where the tide wave is obstructed, it requires to be taken into account.

It has been computed from the tidal constants that M. S. L. is 0·01 ft. above H. T. L. at Sandy Hook, and 0·067 ft. above at Governor's Island. The differences are about the same at Pier A, West 57th st., and East 24th st., as they are at Governor's Island, so far as present information goes, and at Fort Hamilton the difference is estimated to be about 0·03 ft. The Sandy Hook observations, only, have been corrected to H. T. L. at Governor's Island in the above tables.

The settlement of bench marks would make the sea appear to rise in relation to the land by the entire amount of the settlement. Consequently all bench marks should be carefully checked to guard against any change, and this has been done in the case of B. M., and B. M. L. mentioned above.

The accuracy of the tidal averages of H. T. L. obtained from an automatic tide gauge varies somewhat with the type of the instrument employed, and the attention given to it. The results are most accurate where the tidal range is small, and the working scale of the gauge large. An examination of the yearly means of the various tidal observations goes to show that the yearly averages of half tide level should not have a probable error greater than 0·05 ft., although the maximum error may be nearly three times as great. The greater part of this probable error is due, however, not to the inaccuracy of the tide gauge, but to fluctuations of the mean sea level from meteorological causes.

When we examine the daily changes of mean sea level in New York Harbor, we find that they are mainly determined by the velocity and direction of the wind. N.W. and W. winds are the effective agents in depressing the sea level and N.E. and E. winds in raising it.* The mean level has been at times raised

* Des Barres in his charts of New York Harbor published in 1780, says, "Tides rise perpendicularly about seven ft., but are sometimes checked to such a degree by the Westerly or North Westerly winds, as to lower the water on the bar to three fathoms and one-quarter, and Easterly or North Easterly winds have frequently risen it to five fathoms."

or depressed as much as three feet from its average elevation during strong gales in the above directions.

When we pass from the daily changes to the monthly averages of mean sea level, we find a remarkable correspondence between the height of mean sea level and the movement of the northwest and west winds, while the northeast and easterly winds appear to have little effect on these monthly averages. Probably the greater and more uniform effect of the westerly winds, which has been proved by analysis for a long series of years, is due to the fact that they are the prevailing winds, last for a considerable time, have greater intensity, and are effective over large areas, while the easterly winds are more local, and changeable.

The atmospheric pressure does not usually appear to have an important share in determining the monthly values of mean sea level, except as it influences the intensity of the prevailing westerly winds.

These monthly averages show a minimum mean sea level, sharply defined in January, and a maximum mean sea level, not sharply defined in August; while the westerly winds have a maximum sharply defined in January, and a minimum not sharply defined in August. This seasonal difference in elevation of mean sea level averages 0·55 ft. By means of yearly averages we eliminate these seasonal fluctuations as well as all astronomical effects, except that having a period of 19 years, which is so small in this latitude (less than 0·2 inch) that it may be neglected.

Particularly noticeable in the tidal curves is the very considerable depression of half tide level in 1874, and the great elevation of half tide level in 1878. When compared with the curve of atmospheric pressures, it will be noticed that abnormal changes of the barometric pressure occurred in those years, which seem to show that they occasioned the tidal fluctuations.

Tidal elevations and barometric pressures at a number of stations on both sides of the Atlantic show that these atmospheric surges extended over a large area, and similarly affected all tide gauges on the North Atlantic Ocean.

In the year 1900 a marked depression in half tide level is shown by the New York observations. As this same depression was observed at Fernandina, Fla., and other points, we may presume that it took place along the entire Atlantic Coast. At New York City, it appears to have been caused by the unusual strength of the N.W. and W. winds.

In 1901 and 1902 mean sea level at New York City rose to a height not before attained, which was probably due to the low barometric pressure prevailing during those years.

As the effect of the atmospheric pressure and winds on the sea level at any place is the integral of their effects taken over a wide area, while these observations are taken at only one point, a close correspondence is not to be expected, particularly where the locality is at the junction of continental and ocean areas, as in this case.

It has been recently found from the yearly averages of atmospheric pressure at many widely separated places, that abnormal variations of atmospheric pressure occur of considerable duration, which are apparently caused by the surging to and fro of the atmosphere. They affect a very considerable area and have a tendency to recur in periods of about three and eight years, corresponding closely with periodic variations of solar energy received by the earth.

The examination of long series of tidal observations in places scattered over the world discloses very similar periodicities, which are doubtless due in the main to the surging of the barometric pressure before alluded to, and the consequent change in the atmospheric circulation.

Tidal observations from Maine to Florida disclose a striking similarity among the changes in half tide level at all localities on the Atlantic Coast, and the same phenomena have been observed on the shores of the Baltic Sea. It appears quite certain that these fluctuations of yearly half tide level, nearly alike in direction and amount, are due mainly to changes in the mean annual barometric pressure, and the accompanying changes in wind velocities. These periodic fluctuations, never more than a few years in duration and very much alike in extent and direction at all the points embraced in a large area, evidently are changes due entirely to the sea, and can in no way be considered as showing a change in the absolute elevation of the land.

On the other hand, there are no changes in the meterological phenomena which will account for a continuous increase of half tide level for a series of years, such as have been observed at New York from 1875 to 1902, at Boston for the same period, and at Penobscot Bay from 1870 to 1885. Neither will such changes account for the continuous depression of sea level shown by the series of observations at Stockholm, Sweden, commencing in 1774, and verified by numerous observations along the Swedish coast of the Baltic Sea, where it has been found that the land has risen nearly two feet relatively to the sea, while equally reliable observations on the German coast of the Baltic Sea, dating from 1811, show no appreciable change in level.

No long period or continuous variations of atmospheric pressure, winds, temperature, ocean currents, etc., appear to exist to

explain these secular changes in mean sea level, and if such changes did occur, they could hardly explain the difference in amount and direction of the changes of sea level observed at different points. Besides, it is seen from tidal observations on the German coast of the Baltic Sea, the North Sea, and the coast of India, that no continuous change in ocean level has occurred in those places, which would probably be the case if there had been any great or long continued change in absolute ocean levels elsewhere.

We must conclude then, except for minor variations due to meteorological conditions, that it is the land and not the sea which is changing in elevation.

Most of the geological evidence appears to show that the movement of the land relatively to the sea in recent geologic times has been of a cyclic character and confined within narrow limits. There is little geologic evidence to be found in the vicinity of New York of a definite character to indicate depression. It is true that marsh sod can be found outshore from the beach, and below mean sea level; that cedar trees die out on the shore, and that peat bogs and stumps of trees have been found in many places below sea level. These phenomena are to be explained, however, by the inroads of the sea during storms, and by wave action; as well as by the compression and consolidation of the marsh land, which has been known to sink as much as three feet when drained, or loaded with sand. As we leave the shore these apparent evidences of subsidence disappear and in places thoroughly protected from the sea few or none of them are found.

It does not appear from the evidence presented by tidal records, or from historic or geologic evidence, that our sea-coast is in any immediate or serious danger from subsidence of the land, for almost without exception the longest records show the least change, and were it not for the power and efficiency of modern dredging machinery the shoaling of harbors would probably be a more serious affair.

The tidal observations have been taken for so short a time, however, that they can only tell us what has been going on recently, and do not disprove a possible change in ocean elevation too small to be detected within the period of observation.

In conclusion it may be stated with confidence, as the result of an inspection and study of tidal observations on both sides of the Atlantic for the first time brought together,

(1st) That the mean sea level oscillates in an irregular manner, having an average period of about eight years. These oscillations closely resemble one another at many ports distant from each other, and appear to be largely due to changes in

atmospheric pressure, and the resulting changes in wind velocities.

(2d) The above oscillations compensate themselves completely in the course of time, and do not give rise to a continuous movement in a given direction.

(3d) That in addition to the above movements of the sea some ports show a more or less continuous rising of the sea relatively to the adjacent land; others a lowering of the sea level in its relation to the land, and still others maintain a constant relation between the two. These latter make it clear that except for the periodic changes noted above, the sea does not change its level, and that the relative changes are due to land movements.

(4th) At various ports the rate of change in the elevation of mean sea level referred to the adjacent land has not remained constant, but has varied in a considerable degree. All the observations show that for long periods the rate of change is less than took place in some part of that period, and the evidence is strong that the movement is not continuous, but oscillatory and confined within narrow limits.

(5th) The observations at New York City show that since 1875 the land has been subsiding relatively to mean sea level by about 1·45 ft. per century, but from the establishment of the self-registering tide gauge in 1853 to that date, little or no change had occurred, and it is improbable that the present rate of subsidence will be continued indefinitely.

Art. XXXI.—*On the Geology of Brome Mountain, one of the Monteregian Hills;* by John A. Dresser.

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In the western part of the province of Quebec, the basin between the Appalachian Hills on the southeast and the southern edge of the old, but now elevated, Laurentian peneplain* at the northwest, is about eighty miles wide. It is occupied by rocks of Paleozoic age in which the geological scale is represented from Cambrian to Lower Devonian, both inclusive. This basin has a nearly level surface except for the presence of a series of hills, eight in number, known as the Monteregian Hills.† Six of these, namely, Mount Royal, Montarville, Beloeil, Rougemont, Yamaska and Shefford, rise at somewhat regular intervals of about ten miles, and in a nearly east and west line. They thus extend for a distance of fifty miles eastward from Mount Royal and from the city of Montreal at its base. Brome Mountain and Mount Johnson are respectively two and a half and six miles south of Shefford and Beloeil. Mount Royal, which is probably the lowest, is 769·6 feet above mean sea level, while Shefford has an altitude of 1,600 feet. Rougemont, Montarville and Yamaska have not yet been determined. The others are intermediate between the heights given, Brome reaching an altitude of 1500 feet.

Considered physiographically, these hills are of residual origin, having been etched into their present relief by the extensive denudation of the region by which not less than one thousand feet of the plain have been removed. The composition and texture of the rocks which compose these hills have evidently offered so much greater resistance to denuding agencies than was afforded by the surrounding strata as to give the hills their present elevation. Hence they are hills of the butte type.

Reports on the geology of the district, with more or less attention to the petrography of these hills, have been made by Dr. T. Sterry Hunt in 1858, by Sir William Logan in 1863 and by Dr. R. W. Ells in 1894.‡

Dr. F. D. Adams in 1903§ made a general review of these hills and proposed for them the name "Monteregian", (Mons Regius), and also gave a detailed description of Mount Johnson. Fig. 1 of this sketch is reproduced from Dr. Adams' paper. The writer is also indebted to Dr. Adams for valuable advice on many points in connection with this investigation.

* Dr. A. W. G. Wilson, Journal of Geology, vol. xi, No. 7, "The Laurentian Peneplain."

† Dr. F. D. Adams, Journal of Geology, vol. xi, No. 3. "The Monteregian Hills—a Canadian Petrographical Province."

‡ Geological Survey of Canada. § Op. cit.

1

MAP OF
A PORTION OF THE
PROVINCE OF QUEBEC
showing the position of
THE MONTEREGIAN HILLS
Scale of Miles.
VERMONT
Yamaska River
Richelieu River
ISLAND OF MONTREAL
LAKE CHAMPLAIN
LAKE MEMPHREMAGOG
Appalachian Uplift
Brome Mtn.
Shefford Mtn.
Yamaska Mtn.
Mount St. Hilaire
Rougemont
Montarville
Pinnacle
Dunham
Farnham
Abbotsford
Granby
Waterloo
Bedford
Stanbridge
Lake Selby
Lake Brome
Lake Waterloo
Lake Shefford
Lake Boivin
Lake Johnson
Mt. Johnson
St Hyacinthe
St Hilaire
Beloeil
Otterburn Park
St Bruno
Chambly
Beauharnois
Valleyfield
Huntingdon
Ormstown
Lachine
Laprairie
Chateauguay
Caughnawaga
Beauharnois
Vaudreuil
Hudson
Como
Rigaud
Ste Scholastique
Ste Therese
St Eustache
St Jerome
St Lin
L'Assomption
L'Epiphanie
Terrebonne
Repentigny
Pointe Claire
Dorion
Vercheres
Chambly
Iberville
Napierville
St Remi
St Timothee
Ste Martine
Ste Clothilde
Ste Justine
Ste Barbe
Ste Genevieve
Ste Anne
Ste Agathe
Ste Adele
Ste Sophie
Ste Rose
Ste Therese
Ste Jerome
St Jovite
St Sauveur
Ste Marguerite
Ste Lucie
Ste Agathe
Ste Adele
Ste Sophie
Ste Rose
Ste Therese
Ste Jerome
St Jovite
St Sauveur
Ste Marguerite
Ste Lucie

In 1901 the present writer completed a report* on Shefford Mountain which is now in press, and published a résumé of it in the American Geologist for October of that year (vol. xxviii).

The above mentioned investigations have shown that the Monteregian Hills are of igneous origin and are intrusive in their relations to the strata surrounding them. As a petrographical province they are distinguished by two main rock types, one representing a basic magma of the essexite class in the Rosenbusch classification—the other, various types of alkali-syenite. In structure Mount Johnson, and probably Mount Royal, are true volcanic necks, while Shefford has been found to be a laccolite.

It is the purpose of the present paper to outline the main features of Brome Mountain, and to indicate its general relation to the other hills of the Monteregian series that have been thus far studied.

Brome Mountain is the largest hill of this series. It comprises an area of about thirty square miles in the counties of Brome and Shefford. Together with Shefford Mountain, which stands two and a half miles to the north, and is next to it in size, Brome is the most easterly of the Monteregian Hills. In form it is rudely circular. The central portion, about Brome pond, is a nearly level basin two and a half by one and a half miles in extent, and overlain by heavy beds of post-glacial clay. The interior basin has an average altitude of about five hundred feet above sea level, or only a little above the country surrounding the mountains; while the basin is encircled by a rim of hills which rise to heights of from six hundred to one thousand feet above the surrounding plain, or one thousand to fifteen hundred feet above the sea. "Pine Mountain" is the highest point.

In common with the other hills of the Monteregian series, Brome is an igneous mass intrusive through Paleozoic strata. The latter belong to the Sillery division of the Cambrian system on the north, east, and south sides of Brome mountain, and on the west to the Mystic series (D2*b*) of the upper Chazy†.

The latest time at which the intrusion could have taken place is also indicated, though less definitely, by the fact that the igneous rocks are somewhat foliated, and show in places an incipient schistose structure. This is parallel in direction with the schistosity of the surrounding sediments, though much less in degree, and represents a late stage in the folding of the Appalachian uplift. As this was not shared in by the Permo-Carboniferous of the maritime provinces, Brome mountain was formed after the deposition of the upper Chazy sediments and before the close of the Carboniferous period.

* Geological Survey of Canada, vol. xiii, part L.

† Dr. R. W. Ells, Annual Report of the Geological Survey of Canada, 1894.

This age limit virtually agrees with that of the adjacent intrusion of Shefford mountain which shows similar dynamic metamorphism, but cuts slightly later strata, viz., The Farnham black slates (D3*a*), a division of the lower Trenton. The latter, however, do not occur at Brome.

The presence of numerous sedimentary outliers which have been invaded and otherwise altered by the igneous rocks beneath, together with the general character of those rocks, and the absence of any tufaceous material, seems to indicate that Brome mountain is an uncovered laccolite and has never been an active volcano. The evidences of a similar structure at Shefford mountain are most conclusive, and as the distance between the mountains is only two and a half miles, which is less than the smallest diameter of either, they are probably parts of a single laccolite. The correspondence of the rocks in the two masses also favors this view.

Petrography.

The igneous rocks of which Brome mountain is essentially composed belong to three principal types, two of which certainly are the products of separate irruptions, and the third possibly so. The rock of the earliest intrusion is of the Essexite family, according to the Rosenbusch classification, or in the Quantitative Classification* it is a Hessose.

The second is of a syenitic character ranging from Nordmarkite to Nepheline syenite. It is Nordmarkose in the Quantitative Classification. The third, which is of comparatively small extent, is a porphyritic rock which from its microscopic and chemical character is classed as a phyro-laurdalose. Their distribution is shown on the accompanying figure (2).

The nordmarkose distinctly cuts the hessose, but the contact of the laurdalose with the nordmarkose, which completely surrounds it, is everywhere drift-covered so that conclusive evidence of their relations could not be obtained.

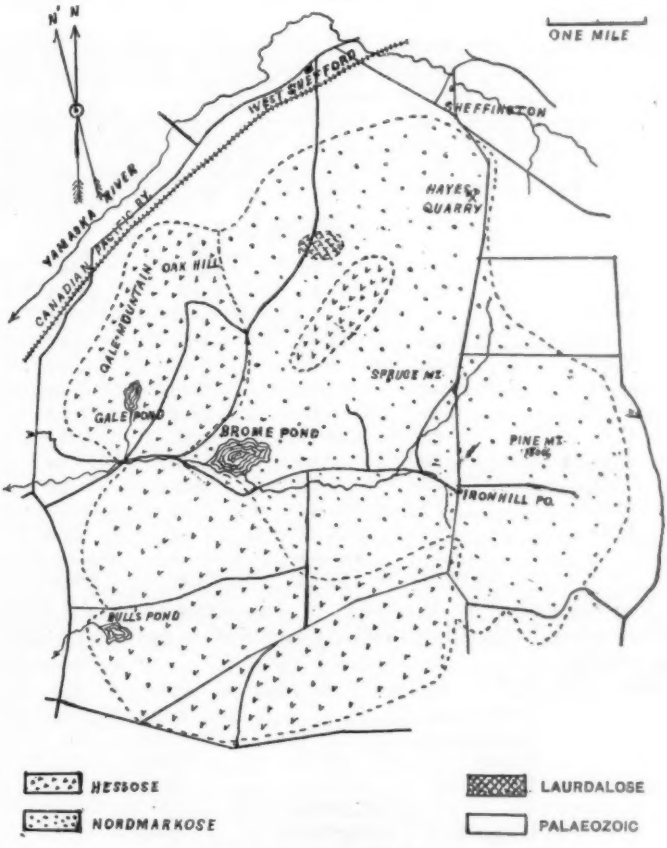
Hessose.—This is a massive rock, gray in color, and weathering to a dull brown. Its structure is granitoid and the texture medium. Feldspar and small amounts of dark minerals, chiefly hornblende, mica, and iron ore, can be seen by the unaided eye.

In the thin section feldspar is found to constitute fully 90 per cent of the rock, in parts that are considered typical, the remaining constituents being pyroxene, olivine, and biotite with accessory magnetite and apatite. Hornblende in many cases occurs quite as abundantly as pyroxene, but in other parts of the rock is entirely wanting. The structure in general is hypidiomorphic granular.

* "Quantitative Classification of Igneous Rocks," Cross, Iddings, Pirsson and Washington, The University of Chicago Press, 1903.

The feldspar is chiefly a plagioclase, which is twinned according to the albite law in broad lamellæ upon which it extinguishes symmetrically an angle of 40 degrees or more. It is bytownite, or basic labradorite. A few rather large crystals of microperthite are the only other feldspathic constituents seen.

2



Map of Brome Mountain, Quebec, Canada.

The hornblende is trichroic, the scheme of absorption being $c > b > a$, with b nearly equal to c. The color ranges from chestnut to yellowish brown. The maximum extinction angle, $c \wedge c$, that was observed was 20 degrees.

The principal variety of augite present is slightly dichroic. Sections having b or c parallel to the plane of the polarizer of

the microscope are gray, or grayish green; those with a in the same position are flesh-colored. In a few instances grains of another variety of augite are possibly present, but the amounts are too small to admit of satisfactory determination.

Olivine, where present, is colorless, and is serpentinized along cracks in the primary mineral:

Biotite occurs in irregular areas having imperfect crystallographic outlines.

Magnetite, sphene, apatite, and occasionally a little nepheline in a decomposed condition are also present but present no features worthy of further notice.

An analysis by Mr. M. F. Connor of the Geological Survey of Canada gave the result I in the following table; II is an analysis of Akerose (Essexite) from Shefford mountain, also by Connor; III, of Andose (Essexite) from Mount Johnson, and IV, the original Essexite from Salem, Mass.

	I.	II.	III.	IV.
SiO_2	44·00	53·15	48·85	47·94
Al_2O_3	27·73	17·64	19·38	17·44
Fe_2O_3	2·36	3·10	4·29	6·84
FeO	3·90	4·65	4·94	6·51
MgO	2·30	2·94	2·00	2·02
CaO	13·94	5·66	7·98	7·47
Na_2O	2·36	5·00	5·44	5·63
K_2O	·45	3·10	1·91	2·79
P_2O_5	·20	·65	1·23	1·04
TiO_2	1·90	1·52	2·47	·20
MnO	·08	·46	·19	----
H_2O	·80	1·10	·68	2·04
	100·01	99·64	99·36	99·92

The calculation of the norm of I in order to refer it to its proper place in the Quantitative Classification gave the following results:

The norm of I:

Orthoclase		2·22
Anorthite		63·90
Albite		14·67
Nepheline		2·84
Diopside	$17CaOSiO_2$, $13MgOSiO_2$, $4FeOSiO_2$	3·80
Olivine	$44MgO, \frac{1}{2}SiO_2$, $12FeO, \frac{1}{2}SiO_2$	4·30
Ilmenite		3·65
Magnetite		3·48
Apatite		·34
Water		·80
		100·00

The rock accordingly falls in

Class II,	Dosalane
Order 5,	Germanare
Rang 4,	Hessase
Subrang 3,	Hessose
	(Grad-polmitic)
	(Sub-Grad. premirlic)

Its actual mineral composition being practically normative, and its structure megascopically granitic, the rock is, therefore, classed as a *grano-hessose.*

2. *Nordmarkose.*—This is also a plutonic rock of medium or coarse texture and gray or reddish gray color. In the hand specimen it shows only feldspar with an occasional speck of biotite.

In the thin section feldspar is found to make up probably 90 per cent of the volume of the rock. The remaining constituents in order of relative abundance are biotite, pyroxene, hornblende, sphene, apatite. Biotite and pyroxene, and occasionally hornblende, may be ranked as essential constituents. Biotite more than equals in amount all the other constituents except feldspar. Occasionally a little nepheline is seen and in other parts a few grains of quartz. Logan mentions* the specific gravity of this rock as 2·632–2·638.

The feldspar resembles orthoclase in its general appearance, but has a mottled look, and under higher powers proves to have a fine perthitic intergrowth in the spotted areas.

These also are found to be more numerous under higher magnifying powers, apparently their extent being limited only by the power of the microscope. The feldspar is, therefore, regarded as cryptoperthite. Logan (op. cit.) reported its specific gravity to be 2·575 and gave the following analysis (V) of selected grains. VI is an analysis of cryptoperthite from Laurvik, Norway, by Gmelin, described by Brögger (Syenitpegmatitgänge, p. 524).

	V.		VI.
SiO_2	65·70		65·90
Al_2O_3	20·80		19·46
CaO	·84		·28
Na_2O	6·52		6·14
K_2O	6·43		6·55
H_2O	·50		·12
		Fe_2O_3	·44
	100·79		98·90

*Geology of Canada, 1863, p. 656.

Hornblende is green in ordinary light and shows pleochroism. It is in so small amounts, however, that the scheme of its absorption could not be satisfactorily determined.

The other minerals require no special note. Where quartz enters into its composition this rock is identical with the Nordmarkose (Nordmarkite) of Shefford Mountain. In other phases it closely resembles the Laurvikite of Southern Norway described by Prof. W. C. Brögger. Its resemblance to both is shown in the following analyses.

	VII.	VIII.	IX.	X.
SiO_2	61·77	58·88	65·43	59·96
Al_2O_3	18·05	20·30	16·96	19·12
Fe_2O_3	1·77	3·63	1·55	1·85
FeO	1·75	2·58	1·53	1·73
MnO	·08	----	·40	·49
CaO	1·54	3·03	1·36	2·24
MgO	·89	·79	·22	·65
Na_2O	6·83	5·73	5·95	6·98
K_2O	5·21	4·50	5·36	4·91
P_2O_5	·15	·54	·02	·14
TiO_2	·74	----	·16	·66
H_2O	1·10	1·01	·82	1·10
	99·97	100·99	99·74 x	99·83 ^

x SO_3	—·06	^ BaO	—·12
		SO_3	—·08
Cl	—·04	Cl	—·14

VII. Nordmarkose, Brome. Analysis by M. F. Connor.
VIII. Laurvikose, Byskoven, near Laurvik, Norway. ("Chemical Analyses of Igneous Rocks," by H. S. Washington.)
IX. Nordmarkose, Shefford. Analysis by M. F. Connor.
X. Laurvikose " " " "

The norm of VII is as follows:

Orthoclase	31·14
Albite	57·11
Anorthite	2·78
Nepheline	·28
Olivine	·62
Diopside	3·16
Apatite	·34
Ilmenite	1·37
Magnetite	2·55
	100·45

The place of the rock in the quantitative classification is as follows:

Class I,	Persalane
Order 5,	Canadare
Rang 1,	Nordmorkase
Subrang 4,	Nordmarkose

In structure it is megascopically granitic and, therefore, becomes a grano-nordmarkose. It, too, is approximately normative. The chief departure of the norm from the mode is in the alkali feldspars, which in the rock are in the form of microperthite.

Laurdalose.—This is a porphyritic rock having a greenish matrix and a few phenocrysts of light gray color.

In the microscopic section the rock is seen to be porphyritic with a felsitic base. The phenocrysts are found to be feldspar, generally of the character of that mineral in the nordmarkose. No plagioclase was certainly seen. Part of the feldspar appears to be pure orthoclase but more possesses the mottled character of cryptoperthite. Patches of granular feldspathic-looking material are also numerous and are prominent in the cryptocrystalline groundmass of the rock. Granular ferromagnesian minerals are also found in some of these aggregates.

Magnetite and apatite in small amount are also present. Sodalite appears in bluish individuals having rounded or polygonal outlines. It is perfectly isotropic, showing no pleochroism, even with a gypsum plate producing red of the first order, and yields no interference figure in condensed light. The dust-like inclusions characteristic of this mineral too are noticeable. A little chlorite and a few individuals of biotite are also seen.

	XI.	X.	XII.
SiO_2	55·68	59·96	55·65
Al_2O_3	20·39	19·12	20 06
Fe_2O_3	2·10	1·85	3·45
FeO	1·95	1·73	1·25
MgO	·80	·65	·78
CaO	1·92	2·24	1·45
Na_2O	9·18	6 98	8·99
K_2O	5·34	4·91	6·07
TiO_2	·60	·66	----
P_2O_5	·06	·14	----
MnO	·31	·49	----
H_2O	1·50	1·10	1·51
	99·83	100·17	99·21

XI. Laurdalose, Brome. Analysis by M. F. Connor.
X. Pulaskite, Shefford (Laurvikose), by M. F. Connor.
XII. Tinguaite, Hedrum, Norway (Laurdalite). Analysis by V. Schemlck. Described by W. C. Brögger. ("Chemical Analyses of Igneous Rocks," H. S. Washington.)

The norm calculated from this analysis is as follows:

Orthoclase	31·69
Albite	27·77
Nepheline	25·56
Acmite	2·31
Diopside	7·85
Olivine	·24
Ilmenite	1·06
Magnetite	1·86
Water	1·50
	99·34

It is therefore classed as follows—.

Class II,	Dosalane
Order 6,	Norgare
Rang 1,	Laurdalase
Subrang 4,	Laurdalose

The structure of this rock is both macroscopically and microscopically porphyritic.

As sodalite is one of the few distinguishable minerals in it, and is indicative of its alkaline character, it might best be designated as a sodalite-bearing felsophyro-laurdalose.

Comparison of Brome and Shefford.

When compared with Shefford Mountain the similarity of the two hills is found to be very close. In Shefford Mountain there have been three separate eruptions and the rocks thus produced in order of intrusion are very similar to those of Brome.

Shefford	Brome
1st, Akerose (Essexite);	1st, Hessose
2d, Nordmarkose (Nordmarkite)	2d, Nordmarkose
3d, Laurvikose (Pulaskite)	3d, Laurdalose

The rocks of the first intrusions in the two hills thus correspond very closely while those of the second are identical, while the third classes do not differ widely.

In point of general structure the hills are practically alike except that dikes later than the main mass of the mountain are very numerous at Shefford while they are almost altogether wanting at Brome.

Chemical Composition of Original Magma.

An effort was made to ascertain the chemical composition of the original magma which produced these rocks. The present surface exposure of the mountain may be taken as affording an average cross section of the mass. Accordingly, the relative

areas occupied by the three rock types at Brome were ascertained by placing a tracing of the map upon a sheet of square ruled paper and counting the squares occupied by each.

Taking the area of laurdalose as the unit, nordmarkose and the hessose occupy 150 and 110 units respectively. Multiplying their analyses by these coefficients of area, and dividing the sum of the products by the sum of the coefficients, the mean of the means obtained is that given as analysis XVII.

The analyses of the three related rocks in Shefford Mountain were treated in a similar manner, and the result given as analysis XIII.

But since the two mountains are to be regarded as parts of the same laccolite it is necessary to find the average of these means. This having due regard for the area of the two masses is found to be that given under XVIII.

	XVII.	XIII.	XVIII.
SiO_2	54 25	59·51	55·47
TiO_2	1·23	·78	1·13
Al_2O_3	22·14	17·90	21·17
Fe_2O_3	2·03	2·17	2·07
FeO	2·66	2·64	2·66
MnO	·12	·45	·20
MgO	1·48	1·27	1·44
CaO	6·77	3·09	5·93
K_2O	3·23	4·46	3·52
Na_2O	4·95	5·98	5·19
P_2O_5	·17	·27	·12
H_2O	·98	1·00	·99
	100·01	99·52 x	99·89
xBaO		·08	
CO_2		·13	
SO_3		·14	
Cl		·08	

A rock having the composition of the mean of Brome Mountain should be classed as follows in the Quantitative Classification:

Class I, Persalane
Order 5, Canadare
Rang 3,—— (alkalicalcic)
Subrang 4,—— (dosodic)

The mean composition of Shefford Mountain, XIII, would be classed thus:

Class II, Dosalane
Order 5, Germanare
Rang 3, Andase
Subrang 4, Andose

Such a rock would stand nearly on the line between the persalanes and the dosalanes, the ratio of the salic to the femic minerals being 85·33 : 12·40.

The average composition of the Brome and Shefford laccolite, as indicated under XVIII, would therefore give a rock which would be classed thus:

Class I, Persalane
Order 5, Canadare
Rang 3,—— (alkalicalcic)
Subrang 4,—— (dosodic)

This agrees with the mean of Brome, and differs but slightly from that of Shefford which stands very near the dividing line between Classes I and II, while they quite agree in the subordinate part of their classification as to Order, Rang and Sub-Rang.

The general mean of the two hills, as well as that of Brome, thus falls in a part of the scheme of the Quantitative Classification that has not yet been occupied. Being hypothetical rocks, however, they do not warrant the introduction of a new name, nor is it necessary, since their position can be otherwise definitely indicated by means of this admirable system of classification.

Art. XXXII.—*The Crystallization of Molybdenite;* by A. J. Moses.

The only satisfactory measurements of molybdenite crystals which have been made are those of Brown* upon material from Frankford, Pa. The earlier measurements of Hörnes were discredited by Kenngott's later examination and those of Knop were evidently made upon bent crystals.

The difficulties in the way of measurement are the striations upon the pyramidal faces which produce multiple and blurred images of the collimator signal and the frequent bending of the crystals as shown by grooves and ridges† upon the cleavage surface which frequently form three systems, each perpendicular to an edge of the hexagonal surface. In some cases these grooves are at many angles without any apparent law.

In a careful examination of a number of molybdenite crystals I have obtained some results which are worthy of record. In some cases, as in the Warren, N. H. crystals, the interpretation of the results may not be the correct one.

1. Molybdenite from Enterprise, near Kingston, Ontario.

In a quantity of material obtained from Mr. C. W. Dickson there was one doubly terminated crystal (fig. 1), about 8^{mm} across by 2^{mm} thick, the pyramidal faces of which were bright, a little curved and almost free from striations, and the terminal plane, which did not appear to be a cleavage, was bright and showed few grooves.

The crystal was attached to a gangue of pyroxene, phlogopite and pyrrhotite but projected so that it was possible to measure the angles between the basal plane and two of the pyramidal faces.

The faces did not yield single images and two separate adjustments were made for each angle with different combinations of lenses. The results, each in itself an average of four or more measurings, were:

First angle.	Second angle.
41° 21½′	41° 28′
41 53	41 02

Average of all, 41° 26′.

This corresponds to a pyramid $(20\bar{2}5)$ the angle for which calculated to Brown's unit would be 41° 23′.

* Proc. Acad. Nat. Sci. Phila., 1896, p. 210.

† Brögger showed (Zeitschr. f. Kryst. x, 507, 1885) that such markings could be produced by pressure, and Mügge attributed them (N. J. f. Min. 1898 i, 109) to translation along the plane 0001 perpendicular to the markings.

2. Molybdenite from Aldfield, Quebec.

A specimen purchased from the Foote Mineral Co. showed a barrel-shaped crystal (fig. 2), the basal plane 7×5^{mm}, thickness 4^{mm}. The cleavage surface was not crumpled and was free from grooves and ridges but was pitted with little etch figures of not very definite shape. The pyramidal planes were striated.

When adjusted on the two-circle goniometer by use of this pitted cleavage surface, it was found that, at intervals of closely 60° of the vertical circle, zones were obtained which yielded images of the collimator signal for two different positions, both positions corresponding to a bright illumination of the entire face. That is, the striations in this crystal are due to an oscillation between two forms and not to gliding or translation, this being further proved by the absence of grooves and ridges on the cleavage.

In each zone one of the two images corresponded to ρ approximately 90°. The crystal was therefore readjusted until these were exactly 90° and the results for the second image thereafter in four zones were:

ϕ	ρ	
0°	77°20′	Dull image
59° 41′	77 21	Single image
120 09	77 10	Brighter of two
180 10	77 22	" " "

Average $\rho=77°\ 18'$.

The variation of both ϕ and ρ are not too great to be attributed to the blurred signals. For the pyramid $(20\bar{2}1)$ observed by Brown at Frankford, Pa., the corresponding calculated angle is 77° 13′.

That is, the crystal consists of a predominant pyramid $(20\bar{2}1)$ with striated faces, and these striæ are due to an oscillation between this form and the prism*.

3. Molybdenite from Cape Breton.

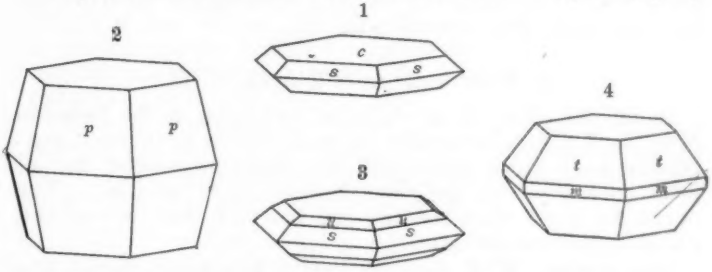
Among a number of small crystals of molybdenite in the Egleston Museum labelled Cape Breton, one small crystal 4^{mm} broad by 1^{mm} thick showed five faces of a pyramid, two of which were unusually bright and intersected in a sharp edge. Placed with this edge vertical in the No. 2 Fuess goniometer, each face yielded a single vertically distorted image and permitted a rather close reading. The interfacial angle obtained was 58° 28½′, which corresponds to an angle with the cleavage of 77° 29′. The calculated angle for $(20\bar{2}1)$ is 77° 13′.

* The faces of such crystals are slightly curved and the crystals taper, preventing an exact application of a hand goniometer. It is probable that the angle $cp=72°$ obtained by Hidden, (this Journal, xxxii, 210, 1886) on Renfrew molybdenite in this way is due to an oscillatory combination.

4. Molybdenite from Okanogan Co., Washington.

Messrs. Geo. L. English & Co. permitted me to examine over one hundred crystals from this locality. Many of these suggested a pyramid approximately the $(20\bar{2}5)$ found upon the crystal from the Enterprise Mine, but the crystals were bent and the faces bruised and rounded. Etch figures $\frac{1}{2}$ to 1^{mm} across and six-sided in cross section were observed and upon one crystal in which they were unusually distinct their parallelism to the hexagonal outline of the crystal was shown by the cross hairs of the microscope. This particular crystal also showed three systems of fine lines *parallel* to the edges of the cleavage in addition to a few coarse grooves perpendicular to these edges.

The best measurements were obtained from a crystal (fig. 3)



which distinctly showed two pyramids, the brighter being the flatter form but the steeper form being more developed. The crystal formed one of a group and only two zones could be adjusted for measurement. The images were multiple but the groups were small and the angles with the cleavage were:

Zone 1.	30° 17′	and	41° 46′
" 2.	29 32		Blurred
Average	29° 54′		41° 46

The nearest *simple* indices are $(10\bar{1}4)$ (28° 51′) and $(20\bar{2}5)$ 41° 23′. If 41° 46′ be taken as the angle of the unit pyramid, the pyramid $(10\bar{1}4)$ would have an angle of 29° 10′.

A crystal, bent like that figured by Knop so that the ridges divided the cleavage into three areas not in the same plane, yielded an angle of 76° 59′ between a pyramidal plane and the adjacent portion of the cleavage.

For $(20\bar{2}1)$ the angle 77° 13′ has been calculated.

5. Molybdenite from the Tilly Foster Iron Mine, Brewsters, N. Y.

Mr. F. V. Cruser presented the Egleston Museum with some specimens of molybdenite found by him at the mine. They occur in a cleavable calcite associated with small bright crys-

tals of green amphibole. On one crystal showing four faces of a pyramid two adjacent faces intersected in an edge which permitted careful adjustment on the Fuess goniometer. Each yielded a bright image of the signal which was only slightly distorted horizontally. The five readings of each face varied with respect to the mean, to the nearest half minute as follows:

First.	Second.
$-14\frac{1}{2}$	$+0\frac{1}{2}$
$+4\frac{1}{2}$	$-6\frac{1}{2}$
$+8\frac{1}{2}$	$-8\frac{1}{2}$
$+6\frac{1}{2}$	$+6\frac{1}{2}$
$-5\frac{1}{2}$	$+8\frac{1}{2}$

The angle obtained was 54° 08′, which corresponds to an angle with the cleavage of 65° 31′. The angle for $(10\bar{1}1)$ on the Frankford, Pa., crystals is 65° 35′.

6. Molybdenite from Warren, N. H.

In an old suite of molybdenite specimens in the Egleston Museum I found a number of small doubly terminated crystals three of which gave with the hand goniometer for all faces an angle with the cleavage between 54° and 55°. The pyramidal faces were striated and most of them curved and the cleavage was curved.

One crystal (fig. 4) showing twelve pyramidal planes was roughly oriented on the two-circle goniometer by the bent cleavage. Three faint signals were obtained with ϕ respectively 60°, 120° and 240°, which were approximately $\rho = 90°$. The crystal was then readjusted until these signals were accurately $\rho = 90°$.

The results were analogous to those obtained with the Aldfield crystal, that is images of the collimator signal were obtained for two different positions, each of which corresponded to a general illumination of the surface. In this case, however, both corresponded to oblique angles (pyramids). The results were

ϕ	ρ		ρ
0°	55° 15′	Two images	64° 36′
60	54 30	Bright image	64 58
119 06′	----		
180 24	Blur		
240 20	54 25	Blurred image	64 18
Average	54° 43′		64° 27′

The simplest interpretation of these angles is that they correspond to $(20\bar{2}3)$ and $(10\bar{1}1)$, for which the corresponding calcu-

lated angles are 55° 45′ and 65° 35′. *Relatively* they are fairly close to calculated angles, for a unit angle of 64° 27′ would require for $(20\bar{2}3)$ an angle of 54° 21′. It is not unreasonable to suppose an error in orientation or in the reading of the faint prismatic signals which would diminish both angles about the same amount.

The conclusion, therefore, is a dominant pyramid $(20\bar{2}3)$ with striations due to an oscillation between this and $(10\bar{1}1)$; the prism $(10\bar{1}0)$ present as a slightly developed modification.

7. *The Knop and Hörnes Measurements.*

The crystals from Auerbach, Hesse, examined by Knop,* were parallel plates often with curved lamellæ. No regular twin striations but frequent wrinkling which appeared to be perpendicular to the sides of the hexagon producing approximations to rhombic thirds of faces. Measurements did not give any constant angles between these 'thirds,' which were evidently results of bending or wrinkling.

Although, as might be expected, these bent crystals gave no constant angles,† it is noteworthy that the averages both of the angles with the cleavage and the angles between adjacent faces closely approach those of the unit pyramid.

	Adjacent faces.	Faces with cleavage.
	50° 07′	71° 0′
	56 49	69 04
	56 37	57 20
Average	54° 31′	65° 48′

The Frankford, Pa., unit pyramid $(10\bar{1}1)$ has angles respectively 54° 10′ and 65° 35′.

With respect to the crystals from Greenland, Hörnes states: "I have measured the crystals from Narksak and found the pyramid 123° 45′, 140° 57′."‡ Kenngott reëxamined§ the crystals and accepted the proof of their hexagonal form but pronounced the pyramid dubious, attributing it to the slipping of curved prisms and to tapering, but states, "one small crystal only showed a fairly distinct acute hexagonal pyramid."

Hintze‖ gives these angles as $pc = 70° 28\frac{1}{2}'$ and $pp = 56° 15'$. There appears to have been a slight error here, as for $pp = 56° 15'$, $pc = 70° 31\frac{1}{2}'$. This corresponds to $(50\bar{5}4)$, for which the calculated angle is 70° 03′.

* Summarized from Neues Jahrb. f. Min., 1848, p. 43.
† Obtained by attaching mica to the faces.
‡ Uebersicht Darstell. des Mohsischen Min. Syst., 1847, p. 115.
§ Min. Forschungen, 1856, p. 104. ‖ Mineralogie, vol. i, p. 104.

Summary of Molybdenite Measurements.

Assuming the unit of Brown, viz., a pyramid *o* making an angle *co* with the cleavage equal 65° 35′ from which $\dot{c}=1{\cdot}908$ is calculated, the observations may be summed up as follows: the angles with the cleavage being given.

Basal pinacoid, *c* (0001). Not observed except possibly on Enterprise, Ont. crystal.

Prism, *m* (10$\bar{1}$0). Frankford, Pa., sometimes prominent, Aldfield, Quebec, as part of striations; Warren, N. H., traces.

Pyramid, *q* (30$\bar{3}$1). Calculated angle 81° 24′.
Observed at Frankford, Pa. Measured angle 81° 31′.

Pyramid, *p* (20$\bar{2}$1). Calculated angle 77° 13′.

Measured angles	Frankford, Pa.	77° 15′
	Aldfield, Quebec	77 18
	Cape Breton	77 29
	Okanogan Co., Washington	76 59

Pyramid, *r* (50$\bar{5}$4). Calculated angle 70° 03′.
Observed at Narksak, Greenland. Measured angle 70° 31½′.

Pyramid, *o* (10$\bar{1}$0). Unit angle, Frankford, Pa., 65° 35′.

Measured angles	Tilly Foster Mine	65° 29′
	Auerbach, Hesse	65 48
	Warren, N. H.	64 27

Pyramid, *t* (20$\bar{2}$3). Calculated angle 55° 45′.
The Warren, N. H., angles for this, 54° 43′, and unit are *relatively* close for these indices but low for the Brown unit.

Pyramid, *s* (20$\bar{2}$5). Calculated angle 41° 23′.

Measured angles	Enterprise, Ontario	41° 26′
	Okanogan Co., Washington	41 46

Pyramid, *u* (10$\bar{1}$4). Calculated angle 28° 51′.
On Okanogan Co., Wash., the angle 29° 54′ was obtained, which was near these indices for 20$\bar{2}$5 = 41° 46′.

Columbia University, January, 1904.

ART. XXXIII.—*The Behavior of Typical Hydrous Chlorides when heated in Hydrogen Chloride;* by F. A. GOOCH and F. M. MCCLENAHAN.

(Contributions from the Kent Chemical Laboratory of Yale University—CXXVI.)

THE halogen salts of the metals are convertible by the action of water to oxy-salts, hydroxides, or oxides with varying degrees of readiness. In order that water may act hydrolytically upon barium chloride, for example, with liberation of hydrogen chloride and substitution of oxygen for chlorine, the temperature of the system must approach low redness, while magnesium chloride is attacked at a much lower temperature, and aluminum chloride is extremely sensitive to the metathetical action of water. These reactions follow the indications of the heat moduli of the transformations. To effect the metathesis between barium chloride and water, with formation of barium hydroxide and hydrogen chloride, a very considerable accession of energy from without the system is needed; the similar reaction between magnesium chloride and water requires less reinforcement from the outside; while the reaction between anhydrous aluminum chloride and water takes place easily. When a hydrous chloride is heated to the temperature of decomposition, the products will be the anhydrous chloride and water, or hydrogen chloride and an oxychloride, oxide or hydroxide, according to the nature of the particular chloride under experimentation. Hydrous barium chloride, $BaCl_2 \cdot 2H_2O$, parts with all its water and becomes anhydrous at 100° C.; the hydrous magnesium chloride, $MgCl_2 \cdot 6H_2O$ may lose a large part of its water at temperatures considerably above 100° without appreciable loss of chlorine, but exchanges chlorine for oxygen with formation of hydrogen chloride at higher temperatures; while hydrous aluminum chloride, $AlCl_3 \cdot 6H_2O$, loses water only with simultaneous formation of hydrogen chloride and exchange of chlorine for oxygen at 100°, and at temperatures at which all water is removed is converted to aluminium oxide.

It is obvious that in those cases in which hydrolytic decomposition takes place at temperatures below those at which the tendency to reversal ceases, the rate of decomposition must be affected by the concentrations of the active products of decomposition. So it is natural to expect that an increase in the concentration of hydrogen chloride in the system will serve to restrain hydrolytic action and decomposition of the chlorides at temperatures of incipient hydrolysis. Dumas* tried to take advantage of this principle in the preparation of anhydrous magnesium chloride, free from oxide, by prolonged drying of

* Ann. Chim. (3), lv, 137.

the hydrous chloride in an atmosphere of hydrogen chloride, but at the temperature of incipient redness at which Dumas worked the reversal of the hydrolytic effect is slow and difficult.

In the case of a hydrous chloride, like barium chloride, which shows no tendency to undergo hydrolytic decomposition at temperatures at which the water is completely removed, there seems to be no reason for anticipating any marked effect upon the progress of the dehydration when hydrogen chloride is made the surrounding atmosphere instead of air. With a hydrous chloride which evolves hydrogen chloride at the temperature of dehydration and forms an oxychloride, oxide or hydroxide the case is different. In such a case the effect of enormously increasing the concentration of hydrogen chloride in the system at the temperatures of incipient hydrolysis will naturally be to restrain the hydrolysis; but whether the result will be the formation of a chloride of lower content of water or an increased stability of the hydrous chloride for some range of temperature will turn upon the affinity of the anhydrous chloride for water.

In the process of dehydrating hydrous aluminum chloride, for example, an increase in the concentration of hydrogen chloride in the system will tend to retard the exchange of hydroxyl for chlorine at the temperature of incipient hydrolysis; but whether the result of such retardation will be the formation of the anhydrous chloride or simply an extension of the range of temperature for which the original hydrous chloride is stable is not immediately obvious, though the high degree of attraction existing between anhydrous aluminum chloride and water, as indicated in the large heat of hydration of that salt, would seem to suggest the latter alternative.

In the work of which an account follows the effect of substituting an atmosphere of hydrogen chloride for ordinary air in experiments upon the dehydration of typical hydrous chlorides was studied. Barium chloride as the representative of salts which lose water without other decomposition, magnesium chloride which suffers some loss of chlorine when fully dehydrated, and aluminum chloride which loses all its chlorine when similarly dehydrated, were the hydrous chlorides taken for these experiments.

In these experiments two combustion tubes of large size set horizontally side by side in a tubulated paraffine bath served as heating chambers. Each tube was fitted with a thermometer and connected through a drying bulb and column with an aspirator. Portions of the hydrous chloride to be treated were weighed into porcelain boats. One of these boats was inserted in each tube about midway in the bath (heated to a regulated temperature) and immediately below the bulb of the thermom-

eter, so that the temperature of the material in the boat might be indicated by the thermometer as nearly as possible. Through one tube was drawn slowly a current of air purified by caustic potash and sulphuric acid, and through the other was sent a slow current of hydrogen chloride, generated in a Kipp generator by the action of sulphuric acid upon sublimed ammonium chloride in lumps. At the expiration of a definite period, the boat was withdrawn, placed in a desiccator and weighed after a suitable interval for cooling. The residue in the boat was dissolved in water, acidulated with nitric acid and the chlorine in it was precipitated by silver nitrate, the silver chloride being weighed on asbestos. Thus it was possible to determine directly the loss of water and chlorine from individual portions of the salt under experimentation during definite intervals and at fixed temperatures, both in an atmosphere of hydrogen chloride and in air, and to find for each individual portion under experiment what proportion of the total loss was hydrogen chloride and what was water. The tabular statements and the diagrams show the course of decomposition of the various salts for the temperatures indicated.

Hydrous Barium Chloride.

For the experiments with barium chloride a well-crystallized specimen showing by analysis a normal content of chlorine was taken. During the process of dehydration at temperatures ranging as high as 100°, at which point all water was expelled, there is no evidence of loss of chlorine, and the course of dehydration, as would be anticipated, appears to be wholly uninfluenced by the presence of hydrogen chloride.

The slight increase in the chlorine generally found in the salt after exposure to the atmosphere of hydrogen chloride may be properly attributed to occlusion or adsorption of hydrogen chloride. The data of individual experiments are gathered in Table I, p. 368, and the general course of action is followed in the diagram.

Hydrous Magnesium Chloride.

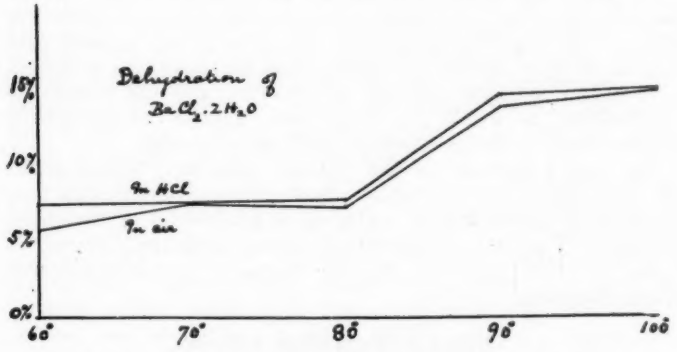
Similar experiments, the data of which are given in Table II, were made with hydrous magnesium chloride dried *in vacuo* over sulphuric acid and of nearly ideal constitution.

So far as these results go, it appears that the loss of chlorine during the process of dehydration of the hydrous magnesium chloride, $MgCl_2 \cdot 6H_2O$, is generally small until a temperature approximating 200° is reached; that at temperatures between 100° and 130° hydrogen chloride generally restrains dehydration, while above that temperature dehydration progresses more

TABLE I.

Ba	56·24
Cl_2	29·02
$2H_2O$	14·74
	100·00

	Atmosphere.	Weights taken. grm.	Loss on heating. grm.	Loss on heating. Per cent.	Chlorine in residue. grm.	Chlorine in residue. Per cent.	Chlorine in residue. Variation from theory.	Water evolved. Per cent.	Time, hrs.	Temperature.
1	Air	0·3335	0·0189	5·67	0·0969	29·06	+0·04	5·67	½	60°
	HCl	0·2952	0·0205	6·94	0·0866	29·34	+0·32	7·27	½	
2	Air	0·3609	0·0262	7·26	0·1045	28·96	−0·06	7·20	½	70°
	HCl	0·3004	0·0213	7·09	0·0875	29·13	+0·11	7·21	½	
3	Air	0·2919	0·0206	7·06	0·0848	29 05	+0·03	7·09	½	80°
	HCl	0·3362	0·0243	7·23	0·0981	29·18	+0·16	7·39	½	
4	Air	0·4161	0·0557	13·38	0·1207	29·01	−0·01	13·37	½	90°
	HCl	0·2972	0·0389	13·09	0·0894	30·08	+1·06	14·18	½	
5	Air	0·4904	0·0711	14·49	0·1423	29·02	0·00	14·50	½	100°
	HCl	0·4272	0·0630	14·75	0·1236	28 93	−0 09	14·64	½	



rapidly in the presence of hydrogen chloride. Hydrogen chloride appears to influence in no very marked and regular way the loss of the first third of the water.

TABLE II.

Mg	11·98
Cl_2	34·87
$6H_2O$	53·15
	100·00

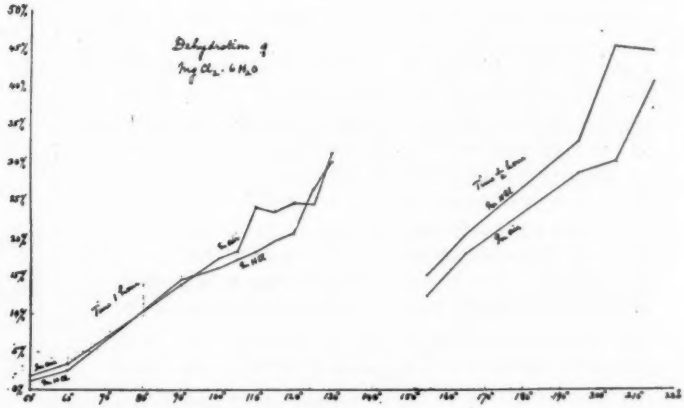
	Atmosphere.	Weight taken. grm.	Loss on heating. grm.	Loss on heating. Per cent.	Chlorine in residue. grm.	Chlorine in residue. Per cent.	Chlorine in residue. Variation from theory.	Water evolved. Per cent.	Time. hrs.	Temperature. C°.
1	Air	0·5004	0 0093	1·85	----	----	----	1·85	1	50
	HCl	0·4330	0·0046	1·06				1·06		
2	Air	0·5139	0·0181	3·52	0·1781	34·66	— ·21	3·31	1	60
	HCl	0·4310	0·0110	2·55	0·1503	34·87	·00	2·55		
3	Air	0·7281	0·0387	5·31	----	----	----	----	1	70
	HCl	0·6093	0·0240	3·93						
4	Air	0·7193	0·1026	14·26	0·2483	34·52	— ·35	13·90	1	90
	HCl	0·6183	0·0900	14·55	0·2155	34·85	— ·02	14·51		
5	Air	0·2854	0·0497	17·41	0·9913	34·79	— ·08	17·33	1	100
	HCl	0·2453	0·0405	16·51	0·8486	34·60	— ·27	16·23		
6	Air	0 5036	0·0927	18·41	0·1755	34·85	— ·02	18·39	1	105
	HCl	0·4591	0·0799	17·40	0·1599	34·83	— ·04	17·36		
7	Air	0·6679	0·1611	24·12	0·2327	34·84	— ·03	24·09	1	110
	HCl	0·5012	0·0908	18·11	0·1750	34·91	+ ·04	18·15		
8	Air	0·5893	0·1404	23·82	0·2055	34·87	·00	23·82	1	115
	HCl	0·5145	0·1018	19·78	0·1801	35·00	+ ·13	19·91		
9	Air	0·5012	0·1314	26·21	0·1678	33·48	—1·39	24·78	1	120
	HCl	0·4542	0·0944	20·78	0·1586	34·92	+ ·05	20·83		
10	Air	0·4249	0·1043	24·55	0·1480	34·85	— ·02	24·53	1	125
	HCl	0·4176	0·1104	26·44	0·1461	34·99	+ ·12	26·56		
11	Air	0·4891	0·1511	30·89	0·1721	35·19	+ ·32	31·21	1	130
	HCl	0·3662	0·1093	29·85	0·1283	35·04	+ ·17	30·02		
12	Air	0·3583	0·0452	12·61	0·1240	34·61	— ·16	12·45	½	155
	HCl	0·3300	0·0503	15·24	0·1151	34·88	+ ·01	15·25		
13	Air	0·3918	0·0716	18·27	0·1359	34·69	— ·18	18·09	½	165
	HCl	0·3964	0·0811	20·46	0·1376	34·71	— ·16	20·30		
14	Air	0·3618	0·1057	29·21	0·1240	34·27	— ·60	28·59	½	195
	HCl	0·3695	0·1225	33·15	0·1278	34·59	— ·28	32·86		
15	Air	0·3330	0·1079	32·40	0·1091	32·76	—2·11	30·13	½	205
	HCl	0·3209	0·1426	44·44	0·1143	35·62	+ ·75	45·21		
16	Air	0·2728	0·1156	42·38	0·0906	33·20	—1·67	40·66	½	215
	HCl	0·3583	0·1671	46·64	0·1179	32·90	—1·97	44·61		

Hydrous Aluminum Chloride.

Pure hydrous aluminum chloride, $AlCl_3 \cdot 6H_2O$, was made by dissolving the C. P. hydrous chloride of the laboratory in the least possible amount of aqueous hydrochloric acid, filtering the solution through asbestos, and saturating the clear solution with gaseous hydrogen chloride. The crystallized chloride thus obtained was collected on asbestos in a perforated cone,

washed with concentrated hydrochloric acid, sucked as dry as possible by the pump, and exposed seventy-two hours in a desiccator containing quicklime, to absorb free hydrogen chloride, as well as sulphuric acid to take up water. The composition of the product was fixed by determining the aluminum as the oxide by ignition with mercuric oxide,* and the chlorine by precipitation with silver nitrate, as shown in the following analyses:

	Analysis I.	Analysis II.	Theory for $AlCl_3 \cdot 6H_2O$.
Aluminum	11·17	11·21	11·20
Chlorine	43·92	44·18	44·05
Water (by difference)	44·91	44·61	44·75
	100·00	100·00	100·00



Weighed portions of this preparation lost practically nothing in three weeks at the ordinary temperature over sulphuric acid, calcium chloride, and phosphorous pentoxide, and remained almost unchanged when heated to 98°.

The details of two parallel series of experiments in which portions of the hydrous aluminum chloride were heated in air or in a current of hydrogen chloride are recorded in Table III, and the course of the change in weight and loss of chlorine at various temperatures in air and in hydrogen chloride are shown in the diagram.

From the results of these experiments it appears that the inhibitive action of the atmosphere of hydrogen chloride upon the dehydration of hydrous aluminum chloride is marked at the lower temperatures. While the hydrous salt when heated in

* Gooch and Havens: This Jour. vi, 45 (1898).

TABLE III.

Al	11·20 per cent
Cl_3	44·05 "
$6H_2O$	44·75 "
	100·00

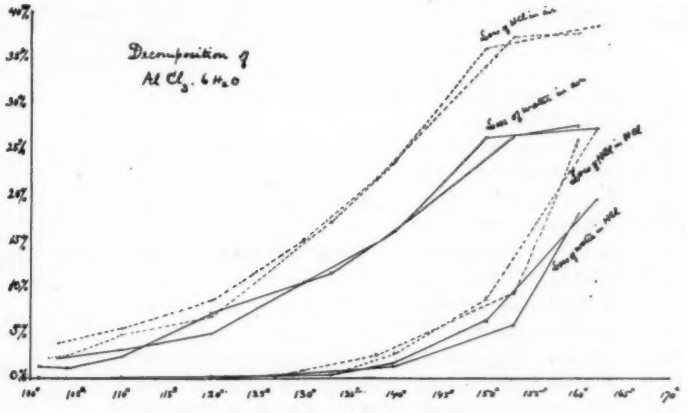
Series I.

Atmosphere.	Weight taken. grm.	Loss on heating. grm.	Loss on heating. Per cent.	Chlorine in residue. grm.	Chlorine in residue. Per cent.	HCl lost. Per cent.	Water lost. Per cent.	Time. hrs.	Temperature. C°.
Air	0·3745	0·0123	3·28	0·1571	41·96	2·15	1·13	1	101
HCl	0·4419	0·0006	·13	....	....	....	....		
Air	0·4314	0·0145	3·36	0·1801	41·75	2·36	1·00	1	104
HCl	0·3725	0·0006	·16	....	....	....	....		
Air	0·3719	0·0261	7·02	0·1467	39·44	4·74	2·28	1	110
HCl	0·4413	0·0008	·18	....	....	....	....		
Air	0·3225	0·0446	13·83	0·1206	37·39	6·84	6·97	1	120
HCl	0·3141	0·0010	·32	....	....	....	....		
Air	0·3725	0·1064	28·56	0·1022	27·43	17·08	11·48	1	133
HCl	0·4583	0·0020	·43	....	....	....	....		
Air	0·5664	0·2254	39·80	0·1182	20·87	23·82	15·98	1	140
HCl	0·4503	0·0207	4·60	0·1860	41·30	2·83	1·77		
Air	0·3503	0·2185	62·38	0·0318	9·08	35·99	26·39	1	150
HCl	0·2563	0·0382	14·90	0·0911	35·54	8·75	6·15		
Air	0·3085	0·2033	65·89	0·0202	6·55	38·56	27·33	1	162
HCl	0·5230	0·2441	46·67	0·0930	17·78	27·01	19·66		

Series II.

Air	0·2292	0·0135	5·89	0·0926	40·40	3·75	2·14	1	103
HCl	0·2425	0·0000	....	....	....	....	....		
Air	0·2855	0·0234	8·20	0·1113	38·97	5·21	2·99	1	110
HCl	0·3139	0·0002	·06	....	....	....	....		
Air	0·3640	0·0482	13·24	0·1307	35·97	8·37	4·87	1	120
HCl	0·2860	0·0005	....	....	....	....	....		
Air	0·2346	0·0596	25·40	0·0687	29·36	15·10	10·30	1	130
HCl	0·2437	0·0022	·90	....	....	....	....		
Air	0·4178	0·1543	36·93	0·0944	22·59	22·04	14·89	1	138
HCl	0·2984	0·0117	3·92	0·1241	41·59	2·53	1·39		
Air	0·3375	0·2159	63·97	0·0260	7·70	37·37	26·60	1	153
HCl	0·3583	0·0539	15·04	0·1258	35·11	9·19	5·85		
Air	0·2425	0·1607	66·27	0·0154	6·35	38·75	27·52	1	160
HCl	0·2512	0·1105	43·99	0·0472	18·79	25·97	18·02		

air loses water appreciably at 101°, the loss in an atmosphere of hydrogen chloride is not considerable until the temperature rises to about 130.° In both cases, however, loss of weight is accompanied by hydrolytic action. At the outset, for every gram-molecule of water liberated approximately a gram-molecule of hydrogen chloride is eliminated: later the proportion of water to the hydrogen chloride increases, because, no doubt, the aluminum hydroxide first formed begins to lose water.



Discussion of Results.

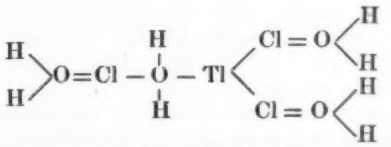
It appears that hydrogen chloride is without influence of any kind in the dehydration of hydrous barium chloride, $BaCl_2 \cdot 2H_2O$, at temperatures not exceeding 100°, at which the process is complete.

In dehydrating hydrous magnesium chloride, $MgCl_2 \cdot 6H_2O$, hydrogen chloride appears to have little or no effect upon the loss of the first third of the water (which may be removed at 100°), to act in restraint of the process of dehydration when the salt is placed at once in an atmosphere heated to a point between 100° and 130°, and to aid dehydration at temperatures above 130°. The hydrolytic dissociation of the salt is not very marked in either air or hydrogen chloride until the temperature approaches 200°.

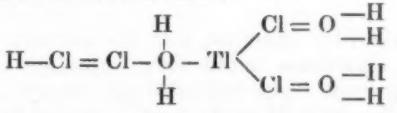
The dehydration of aluminum chloride, $AlCl_3 \cdot 6H_2O$, is inhibited by an atmosphere of hydrogen chloride until a temperature of about 130° is reached. Above that point, as in air above 100°, water and hydrogen chloride are evolved simultaneously.

In attempting to account for the relation of water of crystallization to the general molecular configuration of hydrous

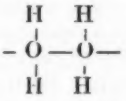
chlorides, Cushman* has proposed to make use of the hypothesis of quadrivalent oxygen in a way to show linkings of stronger and weaker combination. Those molecules of water which are held more firmly than others are placed within the molecular complex, while those molecules of water which admit of easy removal without affecting the constitution of the anhydrous salt are attached externally. According to Cushman, the hydrous thallic chloride may be represented by the symbol



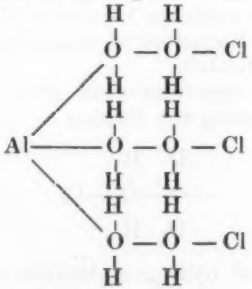
which by placing a single molecule of water within the complex brings to view the observed fact that at the ordinary atmospheric temperatures one molecule of water is held more firmly than the other three. The easy transformation of this salt by the action of hydrochloric acid, as observed by Meyer,† is exhibited by a comparison of the symbol with that of the chlorthallic acid derived from it.



For the molecule of hydrous aluminum chloride Cushman makes the suggestion that the water is held in three linkages



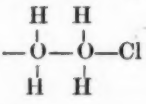
within the complex, according to which the symbol would be



* Am. Chem. Jour., xxvi, 505. † Loc. cit.

This symbol brings out the experimental fact that water cannot be eliminated without simultaneous liberation of hydrogen chloride, at least in the first reaction, and shows that from a molecule thus constituted the formation of aluminum hydroxide or oxide with evolution of water and hydrogen chloride would seem to be natural.

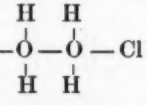
A little consideration makes it obvious, however, that the decomposition of a molecule containing the group



need not in every case result finally in the elimination of all chlorine as hydrochloric acid and the formation of the metallic hydroxide, oxyhydroxide, or oxide. When conditions favor, there would seem to be nothing to prevent more or less secondary reaction of the liberated hydrogen chloride upon the metallic hydroxide first produced. Whether such secondary reaction will take place in any given case will depend largely upon the relative strengths of affinities of which we have, at least in many cases, some sort of measure in the heats of reaction.

It is not likely, for example, that the reaction of hydrogen chloride upon aluminum oxide with formation of aluminum chloride and gaseous water will take place to any considerable degree when the heat of such reaction would be negative to the extent of approximately 27,000 cal. for every gram-molecule of aluminum oxide converted. On the other hand, it is not unreasonable to look for some convertion of magnesium oxide to magnesium chloride by a reaction which involves the liberation of approximately 19,000 calories to the gram-molecule of magnesium oxide attacked. So it appears that an inner linkage such as is suggested by Cushman might possibly exist in the case of such a salt as hydrous magnesium chloride without coming very much into evidence by reason of the evolution of hydrogen chloride and formation of magnesium hydroxide or oxide when the salt is heated.

Turning now to the consideration of what is likely to occur when a molecule possessing the linking

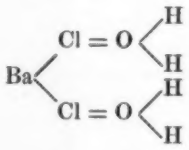


is heated in presence of hydrogen chloride, it is obvious that the first effect of increasing the concentration of hydrogen

chloride at the temperature of incipient decomposition would be to reverse the action of decomposition and to hold the hydrous salt in a condition of greater stability. In the case of a salt which when heated evolves all its chlorine this inhibitive action would be the only effect observed. In the case of salts which give in the decomposition hydroxides or oxides capable of reacting with hydrogen chloride under the conditions with the formation of an anhydrous chloride, the effect of heating in an atmosphere of hydrogen chloride might also be increased stability for a certain range of temperature, but this limit of stability once passed, a second effect of the hydrogen chloride tending to increase the rapidity of the formation of the anhydrous chloride and so to produce a more rapid evolution of water from the salt as compared with the amount of water set free from the salt heated *per se* at the same temperature might become prominent. It is to be expected that one and the same salt might exhibit each of these effects, the one restraining dehydration and the other aiding it, at appropriate temperatures.

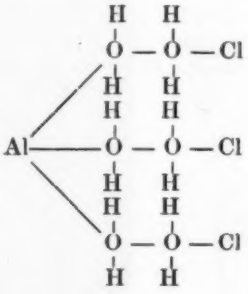
Now, returning to the salts under investigation, we find that the experimental results fall very well into line with the assignment of symbols according to Cushman's hypothesis.

The symbol



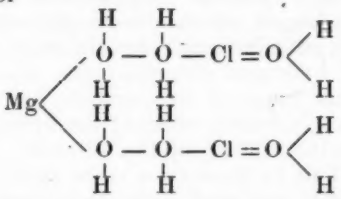
suggests the observed easy detachment of water and the absence of all effect of decomposition of the chloride when the water is removed at 100°, and suggests no reason why any special effect should be anticipated when hydrogen chloride is made the medium in which dehydration takes place.

The symbol



indicates the experimental fact that water cannot be removed from the salt without simultaneous breaking out of hydrogen chloride at least in the primary action, and suggests that increase in the concentration of hydrogen chloride in the system should retard the dehydration of the salt, as was observed.

The symbol

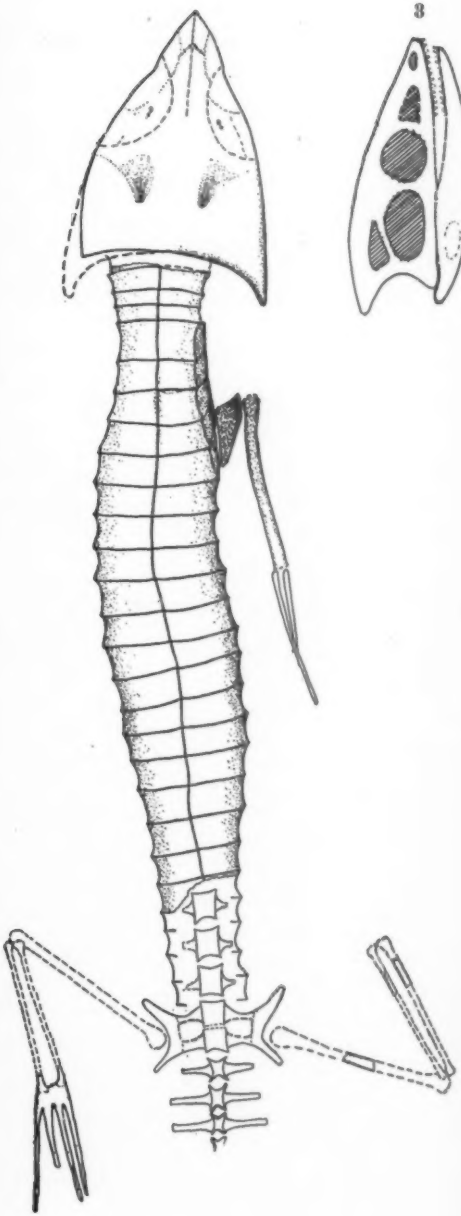


shows that one-third of the water in the salt should be evolved easily and without hydrolytic effect. Thereafter, the atmosphere of hydrogen chloride will act to increase the stability of the chloride now containing four molecules of water within the complex and so to limit the rate of dehydration as compared with that in air for some range of temperature, as was observed between 100° and 130°. The limit of increased stability once passed, the rate of dehydration will depend upon the predominance of the primary effect of decomposition with liberation of water and hydrogen chloride or of the secondary action of hydrogen chloride upon the residual oxide or hydroxide. In case the secondary effect predominates, the rate of dehydration will be greater in the atmosphere of hydrogen chloride, as it was in six out of seven experiments at temperatures between 120 and 215°.

So it appears, that the phenomena of dehydration of the hydrous chlorides under discussion, in the atmosphere of hydrogen chloride as well as when heated *per se*, find reasonable expression upon the hypothesis of varying relations of position of the water within the molecular complex, as suggested by Cushman upon the assumption of quadrivalent oxygen. The behaviour of hydrous chlorides in an atmosphere of hydrogen chloride should in many cases afford means of differentiating the water within the complex from water attached externally.

1

2



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ART. XXXIV.—*On Stegomus Longipes, a New Reptile from the Triassic Sandstones of the Connecticut Valley;* by B. K. EMERSON and F. B. LOOMIS. (With Plate XXII.)

IN spite of the great abundance of tracks preserved in the Triassic sandstones of the Connecticut valley indicating a rich land fauna, the number of osseous remains is limited to three dinosaur specimens and a portion of an Aëtosaurus-like carapace, called by Marsh, Stegomus*. On account of this rarity, the appearance of a new fossil throwing light on the land fauna, and on the makers of the well known tracks, is of general interest.

Some seven years ago, while removing the superficial layers of sandstone in the Hines Quarry, which is about a mile east of the village of East Longmeadow, Mass., Mr. G. B. Robinson found the small lizard-like specimen which is the subject of this paper. It occurred in a dense layer of red sandstone some ten feet below the surface and immediately above the thicker and softer layers which are used commercially for building stone. The discoverer removed the blocks containing the animal to his door yard, where they remained for about seven years exposed to the weather. They were seen by Mr. and Mrs. E. D. White, who obtained possession of them and brought the fossil to Springfield. Mr. and Mrs. White kindly placed this finely preserved fossil at our disposal for study and description.

The specimen consists of three pieces containing the major part of the whole animal. All but a thin interrupted film of the bone has been leached out, leaving spaces which are filled with calcite. It is, then, largely a cast, both the upper and lower surfaces of the bone being impressed on one block or the other. The first block contains most of the fossil, the splitting having exposed the under surface of the bones roofing the head, of the carapace from the head to the pelvis (28 pairs of plates), the bones of the right arm and left foot. The second block contains the impression of the upper surface of the same parts. The third is a chip, flaked off just in front of the pelvis and exposing the vertebræ of that region.

Skull.—This is broadly triangular in outline, tapering to a pointed snout. The upper surface of the cranium seems to have been completely roofed with bone, except possibly directly over the orbit. Two supraorbital bones are distinctly indicated, but between them and the frontals is a space which seems to have been open (see ? in fig. 2, Pl. XXII). Sutures are present

* Marsh, O. C., 1896, this Journal (4), ii, pp. 59–62.

showing that the dermal bones were paired along the middle line. The premaxillæ are short, the nasals are rather long, but the boundaries of the other bones cannot be made out. A vertical break shows the side of the skull imperfectly, as restored in fig. 3, Pl. XXII. The parts actually present are indicated by the complete line, while restoration is indicated by a broken line. It is a low skull, being about one-third as deep as long. The quadratum is well back, making a long jugal arch. An antorbital vacuity is present though its boundaries are very imperfectly indicated. The orbit is moderately large, being distinctly bounded off from the temporal vacuities as indicated. It has above it at least two supraorbital bones. That there is a large lateral temporal vacuity is certain. A forward projection of bone in the squamosal region seems to indicate a dividing arcade between this and a supra-temporal vacuity, but the arcade is not complete and is not therefore certain. On the maxilla of the left side one tooth and a part of a second is preserved, showing them to be tiny conical affairs. The depth of the lower jaw is about 3^{mm}, being a light slender mandible.

Carapace.—The dorsal side of the body was protected by a double row of plates, on either side. Those along the middle line are wide, their outer edges being flanked with small quadrate scutes. From the head to the pelvis there are 28 sets of plates, which are narrow and inflexed in the neck region, widen till the middle of the body is reached, and then gradually taper toward the tail. The arrangement and relations of these scutes are seen in fig. 2. Each plate of the median row is usually about 4–4 $1{\cdot}2^{mm}$ from front to back. The third and fourth, however, are about half as wide as the rest, while the fifth is much the widest, being wider than the two preceding taken together. Possibly some of this variation is due to the curvature of the neck, but most of it is clearly the bone itself. The rear margin of each scute overlapped the front of the succeeding one, as is clear in the cast of the upper surface. Marsh considered that in his specimen this was not the case, but the fossil shows only the under surface of the scutes and they appear exactly as do those in the specimen under description. Marsh used this character to distinguish Stegomus from Aëtosaurus, but the contrasts must be found in other characters, as is shown later. Along the outer margins of plates 5–9 small quadrate scutes were brought into sight by preparation. The nature of the fossil does not permit further preparation, but doubtless similar scutes occur all along the side of the body. On the cast of the upper surface of the scutes, there are indications that the surface was pitted but the coarseness of the sandstone prevents certainty.

Vertebræ.—Three presacrals are exposed, each deeply bicon-

cave and with long transverse processes. Two vertebræ only are involved in the sacrum, their moderately long transverse processes supporting the ilium. How completely they are united is not clear on account of the broken condition of the vertebræ, but they appear slightly separated. Three and a half deeply biconcave caudals are all that are preserved. The transverse processes of these are even longer than on the presacrals and quadrate in section. From the sacrum back they are progressively longer, suggesting a broad flat tail such as is known for Aëtosaurus.

Fore Limb.—Of the pectoral girdle only the scapula is present, and this is a broad triangular bone 9^{mm} long by 5^{mm} deep. Its upper margin lies parallel to small lateral plates 7–9 in the series. The leg is unusually long, the slender humerus being $1\frac{1}{2}^{mm}$ in diameter and 24^{mm} in length, a bone nearly straight and swelling slightly at either end. The radius and ulna are but $\frac{3}{4}^{mm}$ in diameter and 19^{mm} long. As the specimen lies, the radius crosses the ulna, but whether this indicates great flexibility or is mere chance is not to be determined. The fore foot is lacking.

Hind Limb.—An ilium 12^{mm} long, the front and rear ends of which curve strongly outward, is present, but only its rough outline is to be made out. Of the limb bones only short fragments are discernible, where they are broken across; but enough is visible to show the direction and diameter of the bones, and by extending these the length can be approximately found. This indicates a leg slightly longer than the fore leg. The femur was $1\frac{1}{2}^{mm}$ in diameter and 26^{mm} in length (by reconstruction). The tibia and fibula are each about the same size, $\frac{3}{4}^{mm}$ in diameter and 21^{mm} long (by reconstruction). The left foot is well preserved. The individual tarsals are not to be made out. Four toes are well preserved, but a fifth is nowhere even indicated. The length of the toes on the figure is probably a little short, as each seems incomplete at the end. The metapodials are long, but the details of the toes do not come out with certainty, though a slight widening at intervals was taken to indicate the joints, and they are drawn on that supposition.

Comparison.—This animal resembles most closely Marsh's *Stegomus arcuatus*, of which twenty dorsal sets of plates are described. It is a much smaller species and presents most of the important features, thus allowing a conception of the animal and its relationships. *Stegomus longipes* is about one-third the size of the preceding species, which is the only comparison readily made, as Marsh's fossil is so incomplete. It belongs to the Aëtosauridæ* and resembles that genus in many important features, but there are enough characters of weight to demand a separate genus, as established by Marsh. Ornitho-

* Fraas O. 1877, Württemb. naturw. Jahreshefte, xxxiii, Festschrift.

suchus and Erpetosaurus of Newton* also have some features resembling *S. longipes* but are far wider differentiated than the German genus. Aëtosaurus has about twenty-five sets of plates from the head to the pelvis, each consisting of a median pair of large scutes and small quadrate scutes outside these. Stegomus has about twenty-eight exactly similar sets of plates.

In the skull, however, there are marked contrasts. The orbit of both genera is bounded above by extra supraorbital bones, but the orbit of the Aëtosaurus is further back than that of Stegomus: the result of which is that the former has only a single small supra-temporal vacuity, while the latter has at least a very large vacuity, and possibly that divided into a supra-temporal and a lateral temporal vacuity. The Stegomus has a wider skull and above the orbit a vacuity or at least a deep depression. The vertebræ of Aëtosaurus are procœlous, while those of Stegomus are amphicœlous. Ornithosuchus has platycœlous vertebral centra. The sacrum in the other known Aëtosauridæ includes three vertebræ, but in Stegomus only two are united to the ilium. Both the fore and hind limbs of Stegomus are much longer and more slender than the Aëtosaurus, this being the character which has suggested the specific name longipes.

The features above described show this fossil to be the remains of a small armoured lizard-like creature, with long legs. It seems to be a land form and of extreme agility.

The following are the measurements of the principal parts:

Length from snout to root of tail				149mm
Length of skull				35
Breadth of skull in occipital region				27
	(29 allowing for fracture)			
Depth of skull in quadrate region				11
Median Plate 2	8mm	transversely by	4½	longitudinally
" Plate 3	5½	"	" 2	"
" Plate 4	5	"	" 2½	"
" Plate 5	4½	"	" 5	"

The succeeding plates gradually increase transversely up to 10mm at about the middle of the body and then slowly diminish again. All are drawn to scale in figure 2, Pl. XXII.

The vertebral centra in front of the pelvis are 3½mm long by 3mm wide. Caudal vertebræ 3mm long by 2mm wide. The transverse process of the last vertebræ are 6mm long.

EXPLANATION OF PLATE XXII.

FIGURE 1.—*Stegomus Longipes*, photograph natural size.

FIGURE 2.—*Stegomus Longipes*, outline drawing to show details, dotted lines indicating the portions reconstructed.

FIGURE 3.—*Stegomus Longipes*, side view of skull reconstructed.

Amherst College, Mar. 1, 1904.

* Newton E. T. 1894, Phil. Trans., vol. clxxxv, Reptiles of Elgin Sandstones.

ART. XXXV.—*Note on the probable Footprints of Stegomus Longipes;* by R. S. LULL.

THE discovery of a nearly complete specimen of Stegomus in the Triassic sandstones of the Connecticut Valley proves a great boon to the student of footprints, for it at once affords a clue to the interpretation of a most remarkable series of quadrupedal tracks which are included under the ichnite genus Batrachopus (Anisopus) of Hitchcock.

Briefly characterized, these tracks were made by a series of forms truly quadrupedal in gait, with a tetradactyl pes and a pentedactyl manus, the latter being considerably smaller and rarely showing the impression of all of the digits; sometimes four, generally but three leaving their imprints. The phalangeal pads are generally distinct and betray a formula which at once places the group among the diaptosaurian reptiles, while the acuminate claws seem to imply a carnivorous mode of life.

In one feature this genus separates itself sharply from most Reptilia, and that is in the extremely long stride in proportion to the length of the pes, the ratio of foot to step being on the average as one to six; this together with a very narrow trackway, shown by the footprints being nearly in a right line, would indicate a creature with long stilted limbs and a gait like that of a cursorial mammal. Edward Hitchcock (Ichnology of Massachusetts, Boston, 1858, pp. 62, 63) recognized the saurian nature of the group, but could not reconcile the limb proportions with those of any known reptile, hence he reasoned that they might have been mammiferous. The inequality of the fore and hind feet together with the remote age of the impressions suggested to him the marsupials, and he says finally that: "although the marsupial type must have predominated the . . . . crocodilian characters . . . . ought not to be overlooked, and therefore I call the animal a *Loricoid Marsupialoid*."

Footprints of *Batrachopus gracilis* E. Hitchcock, Natural size. A manus, B pes.

Lull, in his recent memoir (Mem. Boston Soc. Nat. Hist, vol. 5, No. 11, p. 482), thought that Batrachopus might represent a survivor of the ancient dinosaurian stem from the very dinosauroid pes, which, though tetradactyl, with all of the digits pointing forward, is of such a character that the typical dinosaurian foot could readily have been derived from it The long-limbed Kadaliosaurus strongly suggested the genus under con-

sideration, which was therefore provisionally placed in the order Protorosauria of Seeley. A comparison was made however between Batrachopus and Aëtiosaurus, but those forms described by Fraas lacked the proportions necessary to correlate the two genera.

In the Aëtiosaur (*Stegomus longipes*), described by Emerson and Loomis on p. 377 of this number, we find a form whose stilted limbs and comparatively narrow body give it just the proportions one would suppose Batrachopus to have, and a careful comparison with the wealth of material contained in the Hitchcock ichnological cabinet of Amherst College seems to correlate it beyond doubt with the species *Batrachopus gracilis* E. Hitchcock, for the correspondence in size is exact.

The genus Batrachopus contains three typical species, *B. deweyanus* E. H., the type species, *B. dispar* Lull, and *B. gracilis* E. H. the last presenting at least two varieties differing from each other mainly in size, each being in this respect comparatively constant, though gradational specimens do occur. Of these varieties the type specimen, the one here figured, that described by Hitchcock,* is of the smaller phase, and it is with this that *Stegomus longipes* agrees, while the larger form is that described and figured in the author's memoir (loc. cit., p. 484, fig. 3). These two forms are mainly from two localities: the typical variety being seen most commonly on a ripple-marked gray shale from the Horse Race near Gill, Massachusetts, the slabs being covered with tracks running in every direction as though the creatures were gregarious in habits, as the specimen of Aëtiosaurus described by Fraas† would also seem to indicate.

The larger variety has its typical locality at the Lily Pond quarry at Turners Falls, Massachusetts, which has yielded so many of Hitchcock's types, and the specimens are for the most part beautifully preserved impressions on a dark red shale, which preserves detail with wonderful fidelity.

Geographically *Batrachopus gracilis* ranges from Massachusetts through Connecticut, New Jersey and Pennsylvania, and hence it is sufficiently numerous and widespread to be among the species most likely to be preserved as fossils.

If one may judge from relative size, it is possible that the footprints of *Stegomus arcuatus* Marsh‡ are those to which the name *Bratrachopus dispar* Lull has been given.

It would seem therefore that the correct placing of Batrachopus would be not among the Protorosauria but in the suborder Aëtiosauria of the order Parasuchia of Huxley.

* Mem. Amer. Acad. Arts and Sci. (2), iii, p. 228, pl. 16, fig. 3, 4.
† Württem. naturwiss. Jahres., xxxiii, 1877.
‡ This Journal (4), ii, p. 59, pl. i.

ART. XXXVI.—*The Canyon City Meteorite from Trinity County, California*; by HENRY A. WARD.

ON page 469 of vol. xxix (1885) of this Journal, Prof. Charles Upham Shepard called attention to a mass of meteoric iron purporting to come from Canyon City, Trinity County, California, whence it had been brought by Captain C. W. Davis of Holmes Hole, Mass., some ten years previous.

Through the kind aid of Mr. A. P. Crowell of Wood's Holl, I was able to find Captain Davis and to obtain the specimen, which the latter gentleman had had in his possession for more than a quarter of a century. Captain Davis' recollections of the finding of the mass were clear, yet with little detail. It was found in the summer of 1875 on the border of a little stream which flows into the Trinity River, and about three

Section of Canyon City Siderite, ½.

miles northeast from the town of Canyon City. It was brought to Captain Davis by John Driver, who discovered it on the surface of the ground. Captain Davis retained it entire during his stay of several years in Canyon City, and subsequently brought it with him to his Massachusetts home, where he had since kept it carefully wrapped in a napkin and had shown it to few visitors.

The form of the specimen was nearly a square, about 8½ by 7½ inches in length and breadth, and 2½ inches in average thickness. One surface was slightly convex, the other slightly concave. The whole surface was much oxidized, and the flaking off of scales of the decomposed iron had entirely obliterated any traces of "pittings" which it originally doubtless had over its surface. The general color of the whole is a dark yellowish brown. The weight before cutting was 18¾ lbs. We have cut several slices from the mass.

The etched sections show a strongly marked octahedral structure with large figures; the plates of kamacite vary much in

size, ranging generally from 1 to 2^{mm} in diameter, with an occasional broader one of from 3 to 4^{mm}, as will be seen in the cut. The bands of tænite are broad and quite prominent throughout the mass, the plessite in many places showing these bands crossing them in parallel layers (Laphamite markings). This is shown particularly well on some of the edges of the slices which have been oxidized, giving the tænite a somewhat comb-like effect from their relief above the weathered kamacite.

No schreibersite was noticed by a macroscopical examination. The largest troilite nodule found in any of the sections is not over 2^{mm} in diameter; others range from this down to a fraction of a mm. These latter were quite abundant, as many as sixteen of them being scattered over some of the slices. On the narrow end of three of the slices is a fissure, entirely crossing the slice, filled with troilite.

Some sections show that the oxidation of the surface had extended inward to the depth of 5^{mm} in some places. This readily accounts for the non-appearance of crust on the exterior surface of the mass, as well as the tendency in some portions to scale; also for the limonitic color of the whole.

The examination of this iron by Prof. Shepard, as noted in the article above referred to, was limited to two small pieces—barely an ounce in all—which were from the outer surface, and "had the appearance of pure limonite." It was thus, as he suggests, difficult to obtain either an exact analysis or exact specific gravity. This circumstance sufficiently accounts for the difference between his analysis and the one lately made by Mr. J. M. Davison of Rochester, N. Y. We give both below:

Shepard.		Davison.	
Iron	88·810	Iron	91·25
Nickel	7·278	Nickel	7·85
Cobalt	0·172	Cobalt	·17
Phosphorus	0·120	Phosphorus	·10
	96·580		99·37
Specific gravity, 7·1		Specific gravity, 7·68	

We have given the name of Canyon City to this iron. The town of that name no longer exists, but was known when Prof. Shepard wrote his paper. Mitchell's Atlas, edition of 1885, has Canyon City on the right bank of a branch of Trinity River in the center of Trinity County, lat. 40° 55′ N., lon. 123° 5′ W. It is satisfactory to be able to thus see rescued from the oblivion of uncertainty a meteorite which for more than a quarter of a century has been mistily known by name yet absent and unknown in substance.

ART. XXXVII.—*Two Microscopic-Petrographical Methods;* by FRED EUGENE WRIGHT.

1. "*The Determination of the Relative Index of Refraction of Minerals in Thin Section.*"*

THE relative index of refraction of two adjacent minerals in thin section can be determined under the microscope in three different ways. (1) By their relative relief, and also by the degree of apparent roughness of their surface (shagreened surface). (2) By the method of Becke's line,† whereby under high power a narrow bright band of light can be seen to travel back and forth, toward and away from one of the two minerals at their intersection as the microscope tube is raised and lowered: the rule then holding good that Becke's line moves toward the mineral with higher index of refraction on raising the microscope tube. This method is sensitive and extremely simple. The only objections to it are that in certain cases two such lines can be seen moving in opposite directions, whereupon it is difficult to decide as to the correct one, and that a certain amount of time is expended in changing from low power to high power. (3) By the method described below, which does not exhibit the two lines occasionally seen in the Becke's method, is equally sensitive and does not require the change from low to high power.

The method is based on principles developed by J. L. C. Schroeder van der Kolk in his recent "Tabellen zur mikroskopischen Bestimmung der Mineralien nach ihrem Brechungsindex,"‡ and is but an application of the same to minerals in thin section.

Mr. Schroeder van der Kolk determines the index of refraction of a mineral by submerging small fragments of the same in a liquid whose index of refraction can be lowered or raised by addition of other liquids until it coincides with that of the mineral, and then measuring the index of refraction of the mixture on a total reflectometer. The method is exact to the second decimal place. Mr. Schroeder van der Kolk gives in his Tabellen a list of over 300 minerals arranged according to their refractive index, and also a list of sixteen or more liquids of variable refractive index suitable to be used in connection with his method.

In actual practice, small fragments more or less lenticular in shape are taken and placed in one of the fluids. If its refrac-

* Compare Tschermak's Miner. Petrogr. Mittheil., vol. xxi, page 238, 1901.

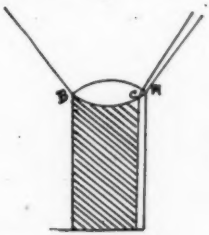
† Sitzungsberichte d. Kaiser. Akademie d. Wissenschaften., vol. cii, page 358-376, 1893.

‡ Wiesbaden, C. W. Kreidels Verlag, 1900.

tive index be higher than that of the liquid, it will act as a lens on the transmitted light and tend to converge the light toward the center (fig. 1); if lower than the surrounding liquid, the effect will be reversed (fig. 2). By cutting off a part of the rays (shaded parts of figs. 1 and 2) the light becomes one-sided in its effect and then exhibits characteristic phenomena. If the fragment AB (fig. 1) be observed under the microscope, the edge AC of the mineral just protruding from the darkened space BC into the light will not be reached by so many beams of light as the surrounding field, and hence will appear darker.

1

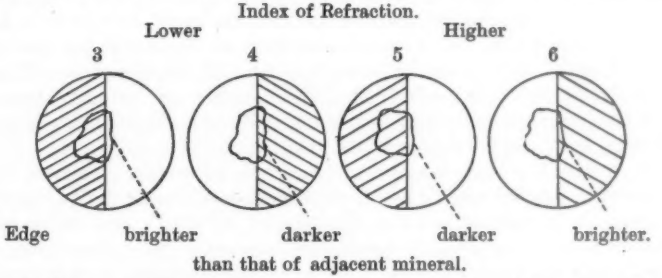
2



In fig. 2, however, the reverse is the case; the point A just outside the dark field is lighted by all the beams between A and C which are thrown together by the influence of the minerals; A will, therefore, appear brighter than the surrounding field. Moreover, as the dispersion is usually much greater for fluids than for solids, it may happen that if the refractive index for yellow rays is the same as that of the enclosing liquid, its index of refraction for red may be lower and for blue rays higher, in which case the mineral acts as a lens for the red rays and converges them toward the center (fig. 1), while the blue rays will be concentrated along the outer edge, A, which will then appear blue. When, therefore, the refractive indices of mineral and liquid are practically the same, bright colored bands appear along the edge of the mineral. Mr. Schroeder van der Kolk describes several experiments which show this phenomenon in an elegant manner. He darkens half the field by placing a small platinum plate over one half the condenser lens beneath the stage.

An adaption of this method, which can be effected with but slight changes, has been found serviceable in petrographic work. In the practical application of the method, the low power is used, condenser lens slightly lowered, and half the field darkened, not by means of the platinum plate mentioned above, but by placing the finger in front of the reflector below the stage and thus casting a shadow over any desired part of the field. The same effect can be produced by moving the

lower iris diaphragm found on some microscopes back and forth, or by using a stop diaphragm. The finger, however, furnishes the simplest means and after some practice is used almost unconsciously. Having thus covered half the field in shadow, observe the mineral section on the border of the shadow. If the mineral projects from the shadow into the light field, and appears still lighter and brighter, its refractive index is lower than that of the adjacent mineral. If the mineral lies within the light field and its edge protrudes slightly into the darkened half, the phenomena are reversed. The four diagrams (3, 4, 5, and 6) show the possible cases which may result.



If the refractive indices of the two are about the same, the colored bands, described above, can often be seen. (Quartz and Canada balsam.)

The phenomena described above are distinct and easy recognizable. By placing the finger before the reflector and lowering the condenser lens slightly, the relative index of refraction of two adjacent minerals can be determined accurately.*

In the diagnosis of minute crystals (as chromite crystals within plates of olivine, etc.) the method has been used to advantage.

2. *On the Use of the Optic Normal in the Microscopic Determination of Minerals.*

Method for Determining the Optical Character of an Anisotropic Mineral on a Section Perpendicular to the Optic Normal. (b ellipsoidal axis.)

In the thin section the only plates of an anisotropic mineral which can be recognized readily by their optical characteristics

*Mr. Geo. W. Corey of the Michigan College of Mines has recently called the attention of the writer to the fact that the relative refractive index of adjacent minerals in the thin section can be ascertained by this method without the aid of the microscope. Observe the thin section with a pocket lens, holding the slide up toward the sky; by placing the finger in front of the thin section and thus casting a shadow over part of the field, the relative index of refraction of two adjacent minerals can be determined by the rules given above; the phenomena observed are identical with those already described.

are those cut perpendicular to the three ellipsoidal axes a, b, c, and the two optic axes (optic binormals); in the uniaxial minerals these quantities reduce to plates cut parallel and perpendicular to the principal axis.

By observing the interference figures on plates perpendicular to the bisectrices a or c of biaxial minerals, we are able to separate the biaxial minerals from the uniaxial. The optical character of the uniaxial minerals whether positive or negative can always be determined, while in the biaxial minerals this can only be effected when the angle between the optic axes in air (2 E) is small (less than 90°)—when both optic axes appear in the field, the angle of which is 70°–90° in ordinary microscopes. For the larger part of biaxial minerals, however, 2 E is greater than 90° and cannot be used as a general factor in the practical separation of minerals by ordinary means. The same holds true for plates cut perpendicular to the optic axes. For this reason the optical character of biaxial minerals is rarely applied in their microscopic diagnosis.

By using the interference phenomena, however, observed in convergent polarized light on plates perpendicular to the optic normal (b ellipsoidal axis in the biaxial minerals, and the normal to the principal axis in the uniaxial minerals), the optical character of the rock-forming minerals can be ascertained by ordinary means.

A plate perpendicular to the optic normal (either uniaxial or biaxial) exhibits a peculiar interference figure in convergent polarized light. On revolving the stage of the microscope, the field becomes dark suddenly, remains so for an instant, only to become light again on further revolution through a few degrees. In the position of darkness the ellipsoidal axes a and b are parallel to the plane of vibration of the nicols. No distinct cross is seen as in the interference figures of plates perpendicular to the bisectrices. The entire field appears dark, with perhaps a weak fringe of light along the outer extremities of the diagonals of the quadrants.

If the field be placed in the dark position and turned slightly, faint, dark hyperbolas can be seen to open and leave the center of the field, similar to the dark hyperbolas of the biaxial interference figures perpendicular to the bisectrices, the chief difference between the two being one of intensity and rapidity of motion. The hyberbolas are very weak and require close observation to be noticed at all. A mineral plate of low birefraction will show them less distinctly than one of high.

Rule.—The dark hyperbolas leave the field in the direction of the acute bisectrix in the biaxial minerals and in the direction of the principal axis in the uniaxial minerals.

Application.—Observe direction in which the faint hyper-

bolas of the interference figure of an optic normal in convergent polarized light leave the field on a slight revolution from position of darkness. Determine value of this ellipsoidal axis (whether a or c) by means of quartz wedge in parallel polarized light and with it the optical character of the mineral; on the same section the birefringence ($\gamma - a$) can also be ascertained; and in monoclinic and triclinic crystals an angle of extinction in general be measured.

Proof.—In uniaxial minerals, the rays travelling parallel to the principal axis suffer no double refraction. The height of the birefringence increases with the angle which the incident ray makes with the principal axis. On observing a section cut parallel to the principal axis in convergent polarized light, the center of the field will become bright for only a slight turn of the stage from the position of darkness, while those rays nearer the principal axis will become less bright for the same angle of revolution. Hence, on rotating the stage from position of darkness of mineral plate to light, the dark weak hyperbolas (less brightly lighted portion) appear to move out in the direction of the least double refraction, i. e. direction of the principal axis.

In the biaxial minerals the acute bisectrix is, in general, direction of lower birefringence than the obtuse. The faint hyperbolas observed in convergent polarized light on a plate parallel to the bisectrices (perpendicular to the b ellipsoidal axis) will, therefore, leave the field in the direction of the acute bisectrix.

The statement that the acute bisectrix in biaxial minerals is direction of less double refraction than the obtuse bisectrix can be proved by elementary means as follows:

Let V be the angle which one optic binormal (optic axis) makes with the least ellipsoidal axis c and a, β, γ, the three indices of refraction.

The equation

$$\cos^2 V = \frac{\frac{1}{\beta^2} - \frac{1}{\gamma^2}}{\frac{1}{a^2} - \frac{1}{\gamma^2}} \quad (1)$$

which express the relation between the angle V and the indices of refraction, reduces, for $V = 45°$, to the form

$$\cos^2 V = \tfrac{1}{2}, \text{ or}$$

$$\frac{\frac{1}{\beta^2} - \frac{1}{\gamma^2}}{\frac{1}{a^2} - \frac{1}{\gamma^2}} = \tfrac{1}{2}$$

*Rosenbusch-Iddings, "Microscopical Physiography of Rock-forming Minerals," 1903, p. 38.

If c be acute bisectrix, then

$$V < 45°$$
$$\cos^2 V > \tfrac{1}{2}, \text{ and, therefore,}$$
$$\frac{\frac{1}{\beta^2} - \frac{1}{\gamma^2}}{\frac{1}{a^2} - \frac{1}{\gamma^2}} > \tfrac{1}{2} \qquad (2)$$

Let

$$\beta - a = C$$
$$\gamma - \beta = A, \text{ or}$$
$$a = \beta - C$$
$$\gamma = \beta + A$$
$$\gamma - a = C + A$$

The expression (2) may now be written

$$2(\beta - C)^2 A(2\beta + A) > \beta^2(C + A)(2\beta + A - C). \qquad (3)$$

On rearranging the quantities of (3), we obtain

$$2\beta(A - C)(\beta^2 - 2CA) + \beta^2(C - A)^2 + 2C^2A^2 - 6\beta^2CA > 0 \qquad (4)$$

To prove that in the case of c acute bisectrix

$$\beta - a < \gamma - \beta$$
$$C < A$$
$$A - C > 0.$$

The value of the expression (4) is evidently dependent on the value of $A - C$, for both A and C are such small quantities (fractions compared to β) that the members of (4) $\beta^2(C - A)^2 + 2C^2A^2 - 4\beta CA$ and usually $6\beta^2CA$ may be neglected in comparison with $2\beta^2(A - C)$. The value of the expression whether greater or less than zero, depends, therefore, generally on the sign of $A - C$ as $2\beta^2$ is always +. Thus when c is acute bisectrix, in general

$$A - C > 0, \text{ or } \beta - a < \gamma - \beta.$$

Hence, the acute bisectrix is, in general, direction of least birefraction. An examination of the list of all biaxial rock-forming minerals confirmed this statement.

Application.—In measuring the extinction angle in any monoclinic mineral in which $b = b$, the optical character of the mineral can also be determined at the same time by the above method. The birefringence $(\gamma - a)$ can likewise be ascertained on the same plate if its thickness be known. The plate cut perpendicular to the optic normal exhibits the strongest double refraction (highest, brightest interference colors), and can be picked out readily from a number of plates of the same mineral cut along various planes. Thus a plate of monoclinic

amphibole or pyroxene ($\mathfrak{b}=b$) parallel to the clinopinacoid 010, on which the extinction angle must be measured, is also suitable to reveal the optical character of the mineral and the double refraction ($\gamma-a$).

Determination of the plagioclase feldspars:

Cleavage faces parallel to the basal pinacoid 001 of the soda-lime feldspars (acid plagioclase), albite to basic andesine, show the optic normal more or less distinctly, and can be determined by the above method as such without further trouble. With this aid in the diagnosis, the separation of the acid plagioclases by the cleavage method on plates parallel to the base (striæ after the albite law) is rendered more certain, as the ambiguity of the sign of extinction is largely eliminated. (The feldspars $Ab_1An_0-Ab_8An_1$ are positive; $Ab_8An_1-Ab_{22}An_{10}$, negative; $Ab_{22}An_{10}-Ab_1An_4$, positive; $Ab_1An_4-Ab_0An_1$, negative.)

In his "Etude sur la Determination des Feldspaths," Michel Levy has plotted a curve illustrating the extinction angles on plagioclase feldspars cut perpendicular to the optic normal ($\mathfrak{b}, n_m$). Unfortunately, the values are so nearly equal in the acid plagioclases that an exact separation of the same is not possible by this method alone. The ambiguity, however, arising from the plus or minus character of the angle between albite and oligoclase and andesine can, in general, be eliminated by the method described above. In the determination of the plagioclase feldspar by the method of Michel Levy in conjunction with the above, a plate cut perpendicular to the optic normal (highest interference color) is first selected, its angle of extinction (angle between the least ellipsoidal axis and the twinning lamellae) measured, the direction of the acute bisectrix noted and its relative value, whether $\mathfrak{a}$ or $\mathfrak{c}$, ascertained by means of the quartz wedge. By combining the extinction angle of any plagioclase with its optical character, the feldspar can in general be determined accurately.

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ART. XXXVIII.—*On the Denucleating Effect of Rotation in case of Air Stored over Water;* by C. BARUS and A. E. WATSON.

1. THE following interesting result was obtained incidentally, in connection with other researches.

If air containing nuclei from any source whatever is introduced into a cylindrical condensation chamber over pure water, and if the cylinder is rotated on its axis more or less rapidly, without further interference with the air contained, the charge of moist air will soon be found to be free from nuclei.

2. The following are examples of the results obtained. Nuclei were produced in dust-free air by passing the X-rays through a cask of paraffined wood, in the direction of an equatorial diameter, for three to five minutes. The cask was 35^{cm} in diameter and 40^{cm} long, mounted axially on an axle and turned by a small electromotor. The coronas were viewed through two longitudinal and diametrically opposite strips of plate glass. Details of construction cannot be considered here; we need merely state that the apparatus during rotation was absolutely free from leakages of nuclei, either of efflux or of influx.

The size of the corona due to nuclei generated by the X-rays is unfortunately very variable, depending (caet. par.) on conditions of radiation beyond the observer's control. Diameters ranging on an arbitrary scale from 6 to 12^{cm} were obtained for the case of rather weak radiation, passing for three to five minutes through the wood of the stationary cask. As a rule, the nuclei vanish in less than three minutes of moderately fast rotation (two turns per second), and the corona obtained thereafter is almost too weak for detection. At these speeds the whole of the water does not yet adhere as a smooth cylindrical apparently rigid sheet to the sides of the cask, but is carried around with more or less turbulent motion.

TABLE I.—Number of nuclei, n, per cub. cm. before and after rotation. Pressure difference about 22^{cm}. Nuclei produced by X-rays to the average number of 30,000 to 70,000 per cub. cm.

Experiment No.	Time of radiation. min.	Time of rotation. min.	Turns per min.	Arbitrary diameter of corona. cm.	n nuclei per cub. cm.
1	3	0	0	4·1	27000
	—	2	140	1·8	2500
	—	4	140	·0	0
2	4	0	0	5·6	69000
	—	6	120	1·1	500
3	3	0	0	1·8	2300
	—	3	64	·0	0
4	3	0	0	2·1	3600
	—	3	230	·5	50

Two reasons may be suggested for the cleansing effect of rotation: It is supposable that eddy currents are produced by the rotation, as a result of which all parts of the confined air are in succession washed on the surrounding surface of water. Such currents, however, could hardly persist but for a short time after the beginning of the rotation. In the second place, if there is churning of the pure water connected with the rotation, the enclosed air must pass in small bubbles through the water many times. This seems to be the more potent cause for the absorption of nuclei. The details of the experiments with X-ray nuclei did not conform very closely with either of these hypotheses, and we therefore decided to investigate the question thoroughly with a larger type of coronas and in a large glass vessel, through which the whole behavior could be better seen.

3. The following results were obtained with a glass cylinder about 35^{cm} long and 25^{cm} in diameter (part of an old electrical machine). It was nicely mounted axially and capable of very rapid rotation, enabling the observer to catch up the whole of

TABLE II.—Air nuclei removed by rotation. $\delta p = 17^{cm}$. Goniometer and lamp 85^{cm} and 250^{cm}, resp. from chamber.

Remarks.	Time of successive rotations. min.	Turns per minute.	s cm.	n nuclei per cub. cm.
Water in a *smooth*	0	?450	10	(200,000)
cylindrical shell;	3		6·4	85,000
fixed to glass walls.	3		6·1	74,000
	4		5·6	57,000
Water in very turbu-	0	350	7·6	140,000
lent motion.	3		3·3	12,000
	3		2·1	3,000
	3		1·2	500
Water in turbulent	0	150	8·8	(160,000)
motion.	3		5·6	57,000
	3		5·4	51,000
	3		4·2	24,000
	3		3·3	13,000
	3		2·8	7,000
	3		2·1	3,000
Time loss of nuclei	0	0	8·7	(160,000)
without rotation.	3		6·8	100,000
Slight subsidence of	3		6·2	77,000
the successive fogs.	3		6·2	77,000

Note: Corrections for periodicity were not applied as it did not seem necessary. The results are thus somewhat irregular. The numbers in parenthesis are estimated.

the enclosed pure water centrifugally, or but a part of it, at pleasure. The difference of the rotational resistances for the two cases is noteworthy.

The angular diameter, θ, of the coronas was determined with a goniometer having a radius $R = 30^{cm}$ long, so that if s is the chord corresponding to R, $\tan \theta/2 = s/2R$. Goniometer and source of light were 85 and 250^{cm}, respectively, from the cylinder, and the exhaustions all corresponded to the pressure difference of about $\delta p = 17^{cm}$, at about 20°.

The results are definite. The first and last parts of Table II show that the time loss of nuclei when the cylinder is rotating so rapidly that the water is held up as a *smooth sheet* against its sides, is not much larger than when the cylinder is stationary, in spite of the fact that in the first case some nuclei must be lost in the turbulent motion on starting and stopping. The law of decrease is as usual apparently geometric.

When the critical speed at which water is caught up on the sides is not attained, in other words, when only a part of the water contained is carried around by rotation, then the cleansing effect is very marked as the middle parts of the table show. Furthermore, nuclei are lost more rapidly per minute as the speed of rotation producing turbulent motion is greater.

Thus it follows that the nuclei are lost by the continued bubbling of the air enclosed within the cylinder through the water contained. This rotational method of making the air dust-free is frequently very convenient, particularly in those cases where slow rotation of the condensation chamber is necessary to keep the air within saturated, and in other cases to be treated elsewhere.

In conclusion, we may observe that if the continuous passage of air in bubbles through water produces ions (as has been shown by J. J. Thomson, Himstedt and others), these ions are not in evidence in the role of condensation nuclei; for the effect of churning pure water, far from being a means of generating nuclei, has in the above experiments been shown to be a very effective method of making the air dust-free. From this point of view we regard the experiments as noteworthy.

Brown University, Providence, R. I.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *The Blue Color of Basic Lanthanum Acetate and Iodine.*—The very remarkable reaction, similar to that of starch, which basic lanthanum acetate gives with free iodine was observed by Damour in 1857, and has been frequently applied for the qualitative detection of the rare earth. The reaction has been studied recently by W. Biltz, who finds that it does not take place when the nitrate is used, and that it is dependent to a large degree upon the physical condition of the precipitate, which should possess the semi-transparent appearance of a colloidal substance. A product that is more pulverulent and white, such as is usually obtained from boiling acetate solutions, gives only a brown color with iodine. After the blue product is once formed, however, the liquid in which it is suspended may be heated to a higher temperature without injury to the color. An addition of indifferent electrolytes, such as potassium nitrate, is also without injurious action, so that the reaction may be obtained from solutions of lanthanum nitrate which have been acidified with acetic acid before precipitation. The reaction always appears with certainty when a solution of iodine in potassium iodide is added to a lanthanum acetate solution, and then enough ammonia is added cautiously, so that the brownish yellow color of iodine does not quite disappear, and finally the liquid is heated very gently. A dark blue precipitate gradually forms, or, if the solution is very dilute, a blue colored liquid is obtained. Quantitative experiments showed that the amount of iodine taken up by the precipitate is very nearly proportional to total amount present in the liquid; hence the conclusion is reached that the phenomenon, like the formation of iodized starch, is one of adsorption, and that the blue substance is not a definite compound.—*Berichte*, xxxvii, 719. H. L. W.

2. *Yellow Antimony.*—It has been known for many years that an unstable, yellow form of arsenic exists, which is analogous to yellow phosphorus. Stock and Guttmann have now succeeded in preparing a yellow modification of antimony by the action of air or oxygen upon liquid hydrogen antimonide at −90°. The substance is spontaneously transformed into the black form even more readily than yellow arsenic; for the change takes place in a few seconds even at −50°, and even at the temperature of its formation, −90°, it is so unstable as to become brownish or blackish in a few hours. The oxidation of hydrogen antimonide at the low temperature used for the preparation of the substance is very slow, so that the yield is small. It was shown that the yellow substance does not contain hydrogen, and that it is soluble in carbon bisulphide at a temperature somewhat higher than −90°, giving a strong yellow color to the solution. Imme-

diately after this solution takes place, separation of black antimony begins.—*Berichte*, xxxvii, 898. H. L. W.

3. *Action of Carbon upon Lime at the Temperature of Fusing Platinum.*—Moissan has heated a mixture of sugar-charcoal and quick-lime in the proportions for the formation of CaC_2, in a tube made of fused quartz, by means of an oxygen and illuminating gas blowpipe flame, to the temperature at which platinum fuses, and has found that at this temperature not a trace of calcium carbide is formed. In this connection the observation was made that silica possesses, even below its point of fusion, an appreciable vapor tension, for at 1200° there were slowly formed upon the lime small needles of an insoluble calcium silicate, a circumstance which prevents the frequent use of a tube of this kind. It was observed also that crystals of calcium carbide were not changed at the fusing-point of platinum, while platinum wire melted at once in solidifying calcium carbide.—*Comptes Rendus*, cxxxviii, 243. H. L. W.

4. *Two Sodium-Ferric Sulphates.* — Skrabal has prepared two double salts, one basic and the other normal in composition, which are interesting from the fact that they correspond to known minerals.

The compound $FeSO_4OH \cdot Na_2SO_4 \cdot 3H_2O$, which agrees in composition with the mineral sideronatrite, is a pale yellow precipitate formed by heating a solution of 50 g. of ferric sulphate acidified with 10^{cc} of dilute (1:6) sulphuric acid and 300 g. of Glauber's salt. The other compound, $Fe_2(SO_4)_3 \cdot 3Na_2SO_4 \cdot 6H_2O$, which corresponds to the mineral ferronatrite, was prepared from a very concentrated solution of 10 g. of ferric sulphate, 100 g. of Glauber's salt and 15^{cc} of concentrated sulphuric acid. This compound is a colorless precipitate.—*Zeitschr. anorgan. Chem.*, xxxviii, 319. H. L. W.

5. *Grundlinien der Anorganischen Chemie*, von Wilhelm Ostwald. Zweite, verbesserte Auflage. 8vo, pp. 808. Leipzig, 1904 (Engelmann).—The first edition of this text-book of elementary inorganic chemistry appeared in 1900. The prompt appearance of this new edition is due in some measure to the fact that 4000 copies of the first edition were sold within three years, and no further comment is needed to show the approval of the chemical public, in Germany at least, in regard to the treatment of elementary chemistry from the standpoint of modern physical chemistry.

No very marked changes have been made in the new edition—the increase in volume amounts to thirteen pages. The author continues to maintain his curious opposition to the atomic and molecular hypotheses, although in this edition he calls molecular weights "molar-weights" in place of the still more ambiguous "normal-weights" of the other edition. It seems entirely inconsistent that he should believe so implicitly in ions but not in atoms and molecules.

Some of the numerous errors of the original book have now

disappeared, but there is no difficulty in finding them here. For instance, the reaction of hydrogen sulphide upon heated copper is given as $H_2S + Cu = CuS + H_2$, whereas it is very well known that Cu_2S would be formed; it is stated that lead tetra-acetate is a yellow salt, instead of a colorless one; and there are several errors in connection with metallurgical topics. H. L. W.

6. *A Manual of Qualitative Chemical Analysis;* by J. F. McGregory. 8vo, pp. xiv, 133. Boston, 1903 (Ginn & Company).—This text-book has been prepared to meet the wants of the author's own classes, as has usually been the case with the great number of books on this subject that have already appeared. Their number shows the existence of much diversity of opinion in regard to the best methods of teaching this branch of chemistry. The book under consideration gives a rather extensive course in the reactions of the radicals, and it seems that all of these are expected to be mastered before their analytical application is taken up. The learning of all these details without applying the knowledge and thus connecting it with analytical processes, is an exceedingly difficult matter, and it appears to the reviewer that this feature is objectionable. The attempt to avoid purely mechanical work on the part of the student by omitting tabular outlines of methods is praiseworthy. The following sweeping statement in the introduction leaves no place for the elements themselves, nor for the many "simple" inorganic substances which are neither acids, bases, nor salts: "Every simple inorganic substance consists of two parts. The first, which is a metal or positive radical, is chemically combined with the second, which is a non-metal or negative radical." The book is marred by the so-called reformed chemical spelling, which leads to incorrect pronunciation and is not in harmony with the rest of the English language as it is now written. H. L. W.

7. *Influence of Temperature and Pressure on the Absorption and Diffusion of Hydrogen by Palladium.*—The following conclusions have been reached by G. N. St. Schmidt: The absorption of hydrogen by palladium follows the phenomena of most absorbing substances above 140° C. That is, it increases with the pressure and diminishes with the temperature. The diffusion increases with the temperature and with the pressure.

This is not true under 140° C. Here enters an irregularity. We are accustomed to consider that in the course of diffusion of a gas through a solid body that first adsorption takes place, then absorption, then diffusion. Diffusion then can only take place if the gas is in the first place adsorbed by the solid body; and this happens only when a certain affinity exists. We must, therefore, assume that under 140° C. no affinity exists between hydrogen and palladium. This enters first at higher temperatures and with it adsorption. There are analogies in chemistry: for instance, carbon and nitrogen do not combine at ordinary temperatures; but at high temperature form CN.

Winkelman has found (Ann. d. Phys., 6, p. 104, 1901; 8, p. 338, 1902) that the amount of diffusion of hydrogen through palladium and platinum is not proportional to the pressure but is relatively greater with diminishing pressure. He explains this by the theory that the diffusion enters with a dissociation of hydrogen molecules and that only the hydrogen atom diffuses. This narrows the working pressure. The forcing pressure is dependent upon the difference of the adsorption on both sides of the body. The diffusing quantity is proportional to this difference. Since it is not shown that this difference is strictly proportional to the pressure, and observations prove that it more or less diminishes with the latter, it necessarily follows that the diffusing quantity is not narrowly proportional to the pressure. The theory that the forcing pressure changes through dissociation of the hydrogen molecule does not appear to be an explanation of the observed irregularity.—*Ann. d. Phys.*, 4, 1904, pp. 747–769.

J. T.

8. *Study of the Radio-activity of Certain Minerals and Mineral Waters.*—In a paper on this subject delivered by the Hon. R. J. Strutt before the Royal Society, there is the following interesting estimate of the quantity of radium in Bath water:

"According to the estimate of Sir A. C. Ramsay, the late Director of the Geological Survey, the salt annually delivered by the Bath spring would be equivalent in volume to a column 9 feet in diameter and 140 feet high. Taking the density to be twice that of water, this would weigh about 500,000 kilograms. The saline residue gives about one-fifteenth the part of the quantity of emanation that samarskite gives. Let us assume that the latter contains one-millionth part of radium, which I think is an outside estimate. At that rate the annual delivery of radium by the spring amounts to about one-third of a gram. The volume of gas which the spring delivered is about one hundred cubic feet per day (Williamson, Brit. Assoc. Reports, 1865, p. 380).

About one-thousandth part of this is helium, so that about three liters of helium are given off daily, or about one thousand liters per annum. The proportion of helium to radium thus indicated is of the same order as in radio-active minerals, though somewhat larger. This is in accordance with the view that the spring draws its supplies from the disintegration of such minerals."—*Nature*, March 27, 1904. J. T.

9. *Atmospheric Radio-activity in High Latitudes.* — A series of determinations of the radio-activity of the atmosphere have been made by G. C. Simpson at Karasjoh, Norway, in 69° 20′ N. lat. It was found that the radio-activity was very much greater than in lower latitudes; the mean for the month being 102, or about six times as great as the German mean for the year (Elster and Geitel at Wolfenbüttel), while the highest value was 432 or nearly seven times the German maximum. As regards the connection with time of day, the maximum was found to fall in the evening, the means for morning and afternoon being

nearly the same. No direct relation was found between the radio-activity and the potential-gradient; temperature and barometric pressure also seemed to have no great influence. The presence of clouds had a marked effect, however, the maximum of 432, for a clear sky, falling to 198, when the sky was completely overcast. Sudden changes were occasionally noted, as from the low value 66 to the high 384 within a few hours. The observations were made in winter when the sun was below the horizon and the surface of the frozen earth was covered with more than two feet of snow.—*Proc. Roy. Soc.*, lxxiii, 209.

10. *The Optical Properties of Vitreous Silica.*—The remarkable properties of vitrified quartz which make it suitable for certain applications in optical work are remarked by Gifford and Shenstone. It has a definite constant composition, unlike glass; is hardly attacked by any corrosive fumes (except F and HF) and is indifferent to solvents. It is also as transparent to ultra-violet radiation as quartz while it has not its double refraction. Its dispersive power is sensibly greater than that of quartz, while the refractive index is low, approaching that of fluorite. A 60° prism, 41^{mm} high by 32^{mm} wide, was made with great care from many hundreds of fine rods of vitreous silica. Another compound prism, $56^{mm} \times 38^{mm}$, was made of four distinct slabs of silica from separate meltings; when finished its performance could not be distinguished from the single prism. Values of the refractive indices for the latter prism are given for a series of wave-lengths from 7950 to 1852·2; for D (Na) the value obtained was 1·4584772. For a thin doublet of fluorite achromatized by vitreous silica it was found that the focal length was almost independent of wave-length.—*Proc. Roy. Soc.*, lxxiii, 201.

11. *Terrestrial Magnetism.*—A Department of International Research in Terrestrial Magnetism has been established by the Trustees of the Carnegie Institution. An appropriation of $20,000 was made for the organization of the work and an annual grant of like amount is expected for carrying it on. Dr. L. A. Bauer, who now has charge of the magnetic work of the Coast and Geodetic Survey, has been appointed Director of the new Department.

II. Geology and Natural History.

1. *United States Geological Survey.*—The following publications have recently been issued:

Twenty-Fourth Annual Report, 1902–1903; by C. D. Walcott, Director. 230 pp., 26 pls.—The amount of work under direction of the Geological Survey may be judged from the size of the appropriation, which last year amounted to $1,377,470. For purely geologic work there was allotted $163,700. A section of Petrology has been created, with Mr. Whitman Cross as geologist in charge. The principles of classification and nomenclature adopted in 1889 have been revised and a new code of

regulations for the making of the Geologic Atlas has been promulgated (pp. 21–28). A special appropriation of $60,000 made it possible to send five field parties into Alaska and the expansion of the work led the Secretary of the Interior to create a Division of Alaskan Mineral Resources in charge of Mr. A. H. Brooks. The section of Physics is conducting experiments upon the behavior of rock-forming minerals and upon the force exerted by growing crystals. Plans have been completed by Dr. A. L. Day and equipment provided for enlarging the scope of this work. The hydrographic work of the United States has reached enormous proportions since the law regarding the reclamation of arid lands was passed. Four divisions now constitute the hydrographic branch—hydrography, hydrology, hydro-economics and reclamation service; and the funds available for this work and not included in the appropriation for the Geological Survey amount to over $3,000,000 annually. The Survey has more than ever the confidence of the scientific and business world.

Monograph No. XLVI. The Menominee Iron-Bearing District of Michigan; by William Shirley Bayley. 513 pp., 43 pls., 54 figs.—This is the sixth and the last of the series of monographs to be published, dealing with the separate iron-bearing districts of the Lake Superior region. Another volume devoted to the general geology of the Lake Superior region as a whole is to follow.

The Menominee district forms a narrow tongue with an area of 112 square miles on the Michigan side of the Menominee River. It has been an important factor in the iron ore production since 1877. The district is bordered by areas of Archean schists and granites. The Huronian sediments of the district, in which occur the ore bodies, lie in a trough between these older rocks. Structurally this trough is a synclinorium composed of several important anticlines and synclines. The Huronian rocks are divided into two series called the Upper and Lower Menominee, which are separated from each other by an unconformity. The Lower Menominee series comprises 1,050 to 1,250 feet of quartzites and conglomerates with 1,000 to 1,500 feet of dolomites. The Upper Menominee series comprises the Vulcan formation, 650 feet thick and the Hanbury slate. The Vulcan formation includes three members, the iron-bearing Traders member, consisting largely of detrital ores and jaspilites, but having basal layers of slate, quartzite and conglomerate; the Brier member, composed of ferruginous and siliceous slates and the Curry member, consisting of quartzites, ferruginous quartzose slates, jaspilites and ores.

The larger ore deposits all rest upon relatively impervious foundations which are in such a position as to constitute pitching troughs. The ores of this district, like those of the Gogebic and Marquette districts, were concentrated by descending waters flowing in definite channels and the general processes involved were the same as those worked out by Van Hise for these other districts.

The book is well and abundantly illustrated and is accompanied by two detailed maps of the region. An introductory outline which serves to give a brief summary of the different chapters is included. W. E. F.

BULLETIN No. 208. Descriptive Geology of Nevada South of the Fortieth Parallel and Adjacent Portions of California; by JOSIAH EDWARD SPURR. 222 pp., 8 pls., 22 figs.—One of the gaps in the geologic map of the United States which has been heretofore unfilled is southern Nevada. This area has now been mapped in a preliminary way as part of the plan to publish a new general geologic map of the United States on the scale of about 40 miles to the inch. Mr. Spurr has confined himself to descriptive matter and has included in his bulletin the results of the geological explorations of Wheeler (1866), Gilbert (1871) and other workers.

No. 218. The Coal Resources of the Yukon, Alaska; by ARTHUR J. COLLIER. 67 pp., 6 pls., 3 figs.—Coal of commercial importance is found at many places along the Yukon River. It occurs in sandstones of Eocene and Upper Cretaceous age. The coal thus far mined ranges from high grade lignite to "rather low grade bituminous." The coal beds are sufficient to supply local demands but "will probably never supply coal for exportation." Fossils, many of them entirely new, were collected from fifty-three localities and have been studied by Drs. Stanton and Knowlton and Mr. Schuchert.

No. 219. The Ore Deposits of Tonopah, Nevada; by J. E. SPURR. 28 pp., 1 pl., 4 figs.—A detailed final report of the interesting Tonopah region from which $4,000,000 were taken the first season will be issued later, and the present bulletin gives only general outlines. The rocks in the immediate vicinity of Tonopah are Tertiary andesite, dacite, rhyolite and basalt with accompanying tuffs. The veins occur in the earliest andesite, and after a period of erosion were capped by later lavas. "The veins were formed by ascending waters succeeding and connected with the early andesite intrusion." There were four periods of hot spring action accompanied by vein formation and mineralization and each of these periods was consequent upon lava intrusion. The ore is gold and silver in the proportion of about 1 : 100 and is unusually free from base metals.

No. 220. Mineral Analyses from the Laboratories of the U. S. Geological Survey, 1880 to 1903; tabulated by F. W. CLARKE, chief chemist. 114 pp.—507 analyses of minerals of over 150 distinct species have been collected from the laboratory records, and published in one bulletin for convenient reference.

No. 221. Bibliography and Index of North American Geology, Palæontology, Petrology and Mineralogy for the year 1902; by F. B. WEEKS. 200 pp.

No. 222. Catalogue and Index of the Publications of the Hayden, King, Powell and Wheeler Surveys; by L. F. SCHMECKEBIER. 208 pp.—The early surveys of the Western United States include

Geological and Geographical Survey of the Territories (Hayden) with publications extending from 1867 to 1878; Geological Exploration of the Fortieth Parallel (King), 1871–80; Geographical and Geological Surveys of the Rocky Mountain Region (Powell); Geographical Surveys West of the 100th Meridian (Wheeler). A vast amount of valuable detail is contained in the publications of these early surveys and a complete catalogue and consolidated index make it available. Investigators, students and librarians will receive this bulletin with hearty thanks.

2. *Fossil Footprints of the Jura-Trias of North America;* by RICHARD SWAN LULL, Ph.D. Memoirs of the Boston Society of Natural History, vol. v, number 11; pp. 461–557, with one plate and numerous text-figures.—The subject of the ichnology of the Connecticut River valley, so remarkably developed by Edward Hitchcock in his works of 1848, 1858 and 1865, has received few scientific contributions for the past forty years. During this period, however, the study of the dinosaurs from the west has very greatly extended the knowledge of early reptiles, so that at the present time the conditions are much more favorable than formerly for a proper interpretation of the problematical footprints. The author has made an exhaustive study of the type specimens of Hitchcock, most of them preserved in the collections at Amherst College, and the results are given in this memoir; his conclusions are here quoted in full from the closing pages.

"The creatures, the record of whose existence has remained impressed upon the ancient shales and sandstones, may be divided into two groups in accordance with their mode of progression: those of bipedal and those of quadrupedal gait. The former, it may be safely assumed, are, in all probability, dinosaurs, for aside from man, many birds, and some modern lizards, they are the only vertebrates whose gait when erect could have been a true walk or run with alternating steps, which without exception the bipedal tracks show, there being no instance of the record of a jumping form. The presence of birds in the new red sandstone has not been proven, lizards are never *habitual* bipeds, man is clearly out of the question, hence by elimination we narrow the possible origin of such tracks down to the dinosaurian forms. This conclusion is strengthened by the presence of the fossil bones of the *Anchisauridae*, a family of primitive carnivorous dinosaurs having affinities with the Megalosauria.

The most abundant of the tracks are attributable to members of that family, creatures ranging in size from about seven to fourteen feet, so truly bipedal that the manus and tail never impress. The pes is tetradactyl, but only exceptionally does the claw of the strong grasping hallux leave a mark. The claws are rather pointed and the whole foot is very bird-like. These footprints form a natural group to which the generic name of Anchisauripus is given and which corresponds to the family *Anchisauridae.*

Allied to Anchisauripus is another carnivorous form whose foot is more specialized than that of the former in the enfeeblement of the hallux and increase of weight which has rendered the foot flatter and its pads more complex. This creature, Gigandipus, reminds one strongly of the Jurassic Allosaurus, though in the latter the claws were probably more trenchant and the whole foot more efficient as a grasping organ. Gigandipus, known from but one specimen, shows a sinuous caudal trace. The dragging of the tail probably was not habitual, but occurred only when the animal was slowing down before stopping.

Another abundant genus is Grallator, characterized by very long limbs and small, compact feet without an impressing hallux and with no tail trace. The proportions of length of limbs to those of feet are the same as in the bustards and the forms which made the tracks were probably aberrant carnivores of habits somewhat similar to those of wading birds, possibly feeding upon feebler reptiles and amphibians, or on fish. In considering the probable relationship of this genus to genera known from their skeletal remains, one is reminded strongly of Ornithomimus, a Cretaceous Compsognathoid dinosaur. Grallator comprises for the most part small forms, the smallest species, *G. gracilis*, indicating a creature but two-thirds the size of Compsognathus, the smallest known dinosaur, whose dimensions may be compared with those of the domestic cat.

Among the habitually bipedal forms, those which never impress the manus, is one group to which the name Eubrontes has been given. It includes larger and heavier forms than Anchisauripus with more blunted claws, but Hitchcock included it with the latter under the name Eubrontes and the later name Brontozoum. The two genera are so different in character that the present author is constrained not only to separate them generically but ordinally as well, for the lack of a grasping hallux, the heavy, slow-moving tread, and the blunter claws are surely not carnivorous characteristics, but seem to point rather to an herbivorous habit of life. It may be that instead of being Orthopod or Predentate dinosaurs the Eubrontes represent another group of aberrant Carnivora, which like the condor (*Sarcorhamphus gryphus*), because of carrion-feeding habits, did not retain the raptorial claws of its predacious allies. The genus Eubrontes while few as to species contains some of the most impressive forms which are fairly numerous as to individuals. *Eubrontes giganteus* represents an animal of massive proportions and of about twenty feet in length, which is nearly the maximum for American Triassic dinosaurs, though much inferior in size to those of the Jurassic and Cretaceous periods. Dinosaurs beyond question herbivorous in their habits, and hence belonging to the order Orthopoda, are the occasionally quadrupedal forms which, though walking on the hind feet, placed the fore feet on the ground while sitting. This shows that on both manus and pes the claws are short and rounded and no longer subserve a

grasping function. The particular interest which attaches to this fact is that it is the first evidence we have of Orthopoda or Predentate dinosaurs in the Trias, for their skeletal remains are entirely unknown either in this country or in Europe from the rocks of that period.

Anomoepus, the most characteristic genus among the herbivorous forms, had a pentadactyl manus with rounded claws and a tetradactyl pes with somewhat longer but still blunted claws. The hallux was but half rotated and therefore ill fitted for grasping, and there was a long metatarsus, or heel, on which the creature rested. The tail sometimes dragged just before the owner came to rest, but at other times was held clear of the ground as a counterpoise to the anterior part of the body as in other genera. Anomoepus represents a group of small, lightly built creatures ranging in size from *A. minimus*, about three feet in length, to *A. crassus*, a New Jersey form, six feet long. They are among the most numerous and interesting of all of the ichnite genera with the exception of Anchisauripus.

The genus Fulicopus, which the writer has separated from the preceding group, shows a greater amount of weight borne on the hind limbs while sitting, the manus resting but lightly as with the kangaroo. The feet resemble those of Anchisauripus more than those of Anomoepus, there being less divarication or diverging of the digits, though the position of the hallux is as in the latter genus. A curious heart-shaped impression frequently occurs just behind and between the impressions of the heels, and this was attributed by Hitchcock to the end of a truncated tail, but the writer believes it to have been made by a callosity beneath the apposed extremities of the ischial bones. Hypsilophodon, of the Wealden of Europe, most nearly suggests the probable skeletal characters of the Anomoepodoid forms, and as Professor Osborn has shown, presents the most primitive characters of any known Orthopod. It is difficult to conjecture the probable habits of Anomoepus, other than that the animals were herbivorous. They probably came to the mud flats mainly for breeding purposes, as their tracks very frequently exhibit a distinct sexual dimorphism between the footprints of the two individuals.

A very striking though rare form, Otozoum, has been placed by the present writer among the Orthopoda, although the structure of its foot is unlike that of any known dinosaur. Otozoum is probably bipedal, though there is a possibility that the great pes may have obliterated the track of the much smaller manus. The foot is plantigrade, tetradactyl, with all of the digits pointing forward and with rounded pellet-like claws and a broadly expanding web or fleshy pad extending some distance beyond the ends of the digits. Its probable function was that of supporting the creature on soft mud rather than a natatorial one. The phalangeal formula of the pes is typically dinosaurian, while that of the manus, 2. 3. 3. 3. 3, is amphibian or cotylosaurian and would be absolutely unique in a dinosaur. The manus is rarely seen and is

so obscure that there is a reasonable doubt as to the correctness of its interpretation. In one instance a dragging tail is shown which is absent in all other specimens and which is evidence in favor of the belief that the animal is a biped. Otozoum has the largest track of all, measuring twenty inches in length, but the author has no conception of the appearance of the creature itself.

Among the so-called leptodactylous or narrow-toed tracks, are many made by bipedal forms which were doubtless dinosaurs, some carnivorous, and some, judging from the manus which is occasionally seen, herbivorous in habits. The subsequent slipping of the mud after the withdrawal of the foot has obliterated most of the morphological characters from the impressions. Some of the leptodactylous forms have been identified with the better known genera and species; others which cannot be so identified because of their obscurity may nevertheless be identical with known forms, while still others evidently do not occur elsewhere. It is a notable fact that while the number of genera and species which have been erected upon these impressions is large, the number of individuals represented is proportionately small, and these are mainly from one or two localities.

Of the truly quadrupedal forms the most interesting is Batrachopus, whose long limbs, tetradactyl, plantigrade pes with acuminate claws, and phalangeal formula of 2. 3. 4. 5, and whose pentadactyl manus are such as one would expect to find in the dinosaurian ancestor. It seems possible, therefore, that Batrachopus represents a persistent type whose affinities are near the dinosaur stem form and which should be classed with Kadaliosaurus in the superorder Diaptosauria of Osborn. Batrachopus may have been a true dinosaur which had retained, among other primitive characters, the ancestral quadrupedal gait. The mode of progression was a true walk like that of a mammal and not the sprawling crawl of modern reptiles. Batrachopus included small forms of carnivorous habits.

There remain other quadrupedal forms, generally of small size, whose tracks, aside from the number of digits, size of the foot, and the length of limb, afford almost no date whereon to base a theory as to their affinities. Professor Osborn has likened ichnological interpretation to the deciphering of ancient cuneiform inscriptions which are utterly unintelligible unless one possesses the key. That the key to the deciphering of the dinosauroid tracks has been found seems evident, but in the attempt at the interpretation of the obscurer quadrupedal footprints the student is still very much in the dark."

3. *The Non-metallic Minerals; their Occurrence and Uses;* by GEORGE P. MERRILL, Head Curator of Geology in the U. S. National Museum, etc. Pp. xi, 414. New York, 1904 (John Wiley & Sons).—This work has grown out of the author's Guide to the Collections in Applied Geology in the U. S. National Museum. While it does not attempt to be a complete text-book, it brings together a large amount of interesting data in regard

to the uses of the non-metallic minerals and their occurrence and mining, particularly with reference to the localities in this country. The mineralogist will find it a useful and instructive volume to accompany the usual text-books, and to the practical worker it will be an almost indispensable compendium of information not easily found elsewhere. A series of thirty-two plates are introduced in addition to text figures; many of these are devoted to views of mineral quarries.

4. *Lehrbuch der Mineralogie;* von MAX BAUER. Zweite, völlig neubearbeitete Auflage. Mit 670 figuren. Pp. xii, 924. Stuttgart, 1904 (E. Nägele).—This second edition of the well-known text-book by Professor Bauer gives evidence in its size of the progress which the science has made since the first edition was published in 1886. The volume now runs to nearly one thousand pages, of which about one-half are devoted to the physical and chemical characters of the species. The matter has been rewritten throughout from the modern standpoint and brought strictly up to date, as is particularly obvious in the chapters devoted to Crystallography. The descriptions of species are full and the general statement of characters which precedes each group adds much to the clearness of the whole discussion.

5. *Annual Bulletin of the Mineral Resources of Kansas,* 1903; by ERASMUS HAWORTH, State Geologist. Pp. 135, Lawrence, Kansas, 1903 (The University Geological Survey of Kansas).—The total production of the mining metallurgical industries of Kansas amounted to over $23,000,000 in 1902, a much larger sum than has been reached before. The most important developments of the year were in the production of coal, the yield of which was upward of 5,000,000 tons, and also of oil and gas from localities in the southeastern part of the state.

6. *A Bibliography of the Geology, Mineralogy and Paleontology of Brazil;* by JOHN C. BRANNER. Pp. 115, 4to. From vol. xii of the Archivos do Museu Nacional do Rio de Janeiro, 1903.—This is the first comprehensive bibliography of the geology of Brazil and contains 1203 titles, not including abstracts and reviews. The author remarks that the great bulk of the geological work in the country has been done by Eschwege and by Derby, the influence of the latter having been particularly important.

7. *The Willamette Meteorite;* by HENRY A. WARD. Proceedings of the Rochester Academy of Science, iv, pp. 137–148.—The Willamette meteorite was discovered near the border of Clackamas County, Oregon, in the autumn of 1902. It is remarkable for its very great size, its extreme dimensions as taken by Mr. Ward being as follows: Length, 10 ft. 3½ in.; breadth, 7 ft.; vertical height, 4 ft.; circumference of base, 25 ft. 4 in. It has a roughly conical form, with an oval base and dome-like summit. Its weight is estimated as being approximately 13½ tons. When the mass was found the cone-shaped portion was below, while the flat base was near the surface of the ground. The former, which

was obviously the front side in the progress of the meteorite though the air, shows in the first place a border area quite covered with the usual pittings; also a number of round well-defined bore-holes mostly near the lower border explained by the disappearance of cylindrical nodules of some sulphide as troilite; and, finally a series of deep open basins and broad channels of great size, which are regarded as owing their origin to the friction of the compressed air in the rapid passage of the meteorite. The base of the mass, 10 ft. × 7 ft. in dimensions, is also remarkable in another way, since the once continuous surface is now largely replaced by a labyrinth of basin-like cavities, some of them very large. These are believed to have been formed by the decomposition of the mass under the action of terrestrial agencies, chiefly water, as it lay for an unknown period with the side exposed. An etched surface of the iron shows the usual crystalline figures and assigns the meteorite a place in the group of octahedral irons. The analysis shows that the mass contains 8 per cent of nickel. The plates accompanying the paper give striking views of the remarkable features of this extraordinary mass. The ownership is at present the subject of litigation, so that the final disposition of the specimen is yet in doubt.

8. *British Tyroglyphidæ;* by ALBERT D. MICHAEL. Volume I, 1901, pp. xiii + 291; plates xix; Volume II, 1903, pp. vii + 183; plates xxxix. London (The Ray Society).—Mr. Michael's ability as a student of Acarina was well demonstrated by his excellent monograph of the Oribatidae, published by the Ray Society in the 40th year of the Society (1883) and the 44th year (1887). His work upon the Tyroglyphidæ has, therefore, naturally attracted much attention from systematic workers in Arachnology. The first volume contains a full history of literature, an account of the classification, an extended description of the external and internal anatomy, and a chapter on the development of the immature stages. These chapters are followed by Part II, which contains systematic descriptions of the genera and species through the important and remarkable genus Glycyphagus. The second volume, beginning with the genus Chortoglyphus, completes the British fauna in this important family. There is added to this a list of the species foreign to Great Britain, and a bibliography. In his review of the classification of the Acarina, Mr. Michael, I think, does an inadvertent injustice to an American author, Mr. Nathan Banks, in his criticism of Banks's classification published in 1894. In the classification of the American writer little attempt was made at novelty in the characters employed. It was based upon the previous classifications of Canestrini and Trouessart, and, with slight modifications of these systems, consisted mainly in the erection of the principal groups into superfamilies with the "oidea" termination now generally adopted by systematic zoologists as indicative of superfamily rank. The points criticised by Michael in the classification are points originated by Trouessart and Canestrini and not by Banks.

The group Tyroglyphidæ is a most interesting and important one, comprising, as it does, species which occur commonly upon flour and meal, upon cheese, upon dried vegetables and drugs, and upon various plant growths, usually moribund but occasionally probably healthy. Interesting errors have occurred in previous observations upon mites of this family, and especially the striking blunder of Cross, who believed that he had created one species in his galvanic batteries. Another error has been the description of species brought up as living in the depths of the sea, when, in reality, the dredge had picked them off the surface of the water on which they were floating. Systematists in other groups in zoology will be interested to note that Mr. Michael seems not disposed to agree to the opinion of the committee of the International Zoological Congress, that the rule abolishing names founded upon larval forms should hold with the Acarina. Economic entomologists will be especially interested in Mr. Michael's conclusion that *Tyroglyphus phylloxeræ* Riley, a species which was supposed to feed on the grape vine phylloxera and which was imported from the United States into France to destroy this great pest, is a synonym of *T. mycophagus* Mégnin, does not feed on living insects, and already existed in France. The plates are very carefully done and are very beautiful. To the reader not previously informed concerning the anatomy of the species of Glycyphagus, for example, the representation of several species of this genus may be a revelation. L. O. HOWARD.

III. Miscellaneous Scientific Intelligence.

1. *National Academy of Sciences.*—The spring meeting of the National Academy was held at Washington, April 19 to 22.

Four new members were elected at this meeting: William Morris Davis, Harvard University; William Fogg Osgood, Harvard University; William T. Councilman, Harvard Medical School; John U. Nef, Professor of Chemistry, Chicago University.

The following foreign associates were also elected: Prof. Dr. Paul Ehrlich, Frankfurt; Prof. Dr. H. Rosenbusch, Heidelberg; Prof. Emil Fischer, Berlin; Sir William Ramsay, London; Sir William Huggins, London; Prof. Geo. H. Darwin, Cambridge; Prof. Hugo de Vries, Amsterdam; Prof. Ludwig Boltzmann, Vienna. The Draper gold medal was presented to Prof. George E. Hale of the Yerkes Observatory, for his researches in astrophysics.

The following is the list of papers presented:

E. L. Nichols and Ernest Merritt: On fluorescence spectra.
John Trowbridge: Spectra of gas at high temperatures.
Theodore Lyman: Short wave-lengths of light.
H. W. Morse: Spectra produced by the Wehnelt interrupter.
George F. Barker: Note on radio-activity and autoluminescence.
R. S. Woodward: A double suspension apparatus for determining the acceleration of gravity. The compressibility of the earth's mass required by the Laplacian law of density distribution.

HENRY L. ABBOT: The disposition of rainfall in the basin of the Chagres.
A. F. ZAHM: Surface friction of the air at speeds below 40 feet a second.
R. H. CHITTENDEN: Physiological economy in nutrition, with special reference to the minimal proteid requirement of the healthy man.
HENRY F. OSBORN: Recent paleontological discoveries by the American Museum exploring parties. Reclassification of the Reptilia.
W. D. MATTHEW: Position of the limbs in the Sauropoda.
HORATIO C. WOOD, JR.: A preliminary report upon Apocynum cannabinum.
ARTHUR T. HADLEY: Biographical memoir of James Hadley.
CHARLES L. JACKSON: Biographical memoir of Henry Barker Hill.
ALEXANDER GRAHAM BELL: The multi-nippled sheep of Beinn Bhreagh.
SIMON NEWCOMB: Application of new statistical methods to the question of the causes influencing sex.
C. S. PEIRCE: Note on the simplest possible branch of mathematics.

2. *Report of the Superintendent of the Coast and Geodetic Survey, showing the Progress of the Work from July 1, 1902 to June 30, 1903.* Pp. 1032, 4to, with numerous plates and sketch maps. Washington, 1903.—This volume contains the usual report (pp. 1–22) by the superintendent, O. H. Tittmannn, of the work accomplished by the Survey in the year ending June 30, 1903. Then follow seven Appendixes on details of field and of office operations; on precise leveling in the United States 1900–3; on triangulation southward along the ninety-eighth meridian in 1902; on magnetic observations from July 1, 1902 to June 30, 1903, etc.

3. *The 1900 Solar Eclipse Expedition of the Astrophysical Observatory of the Smithsonian Institution;* by S. P. LANGLEY, Director, aided by C. G. ABBOT. Pp. 26 with twenty-two plates. Washington, 1904.—The official report of the highly successful observations of the 1900 solar eclipse by the Smithsonian party at Wadesboro, N. C., is here presented. Of the accompanying plates the first gives a striking general view of the corona obtained from a 82-second exposure with the 11-foot focus camera; other beautiful plates give detailed illustrations of portions of the inner corona from 16-second exposure with the 135-foot focus camera, etc.

4. *Physique du Globe et Meteorologie;* par A. BERGET. Pp. 353; 128 figures and 14 colored double-page plates. Paris, 1903 (C. Naud).—This volume is the basis of an elementary course which the author is conducting at the Sorbonne, and appears at the suggestion of M. Velain. It is a serious and, on the whole, rather successful effort to collect all of the known facts that bear on meteorology. It is essentially non-mathematical; even elementary mathematical discussions being separated from the text proper by smaller type.

The book is divided into three parts, the first treating of terrestrial physics; 124 pages being devoted to the discussion of the size and position of the earth, its movements, determination of its density, universal gravitation, cosmogony, geodesy, the methods of determining g, with historical treatment, and terrestrial magnetism.

The second part deals with the physics of the ocean; its constitution, tides, the propagation of waves and currents are considered. The remainder of the book is devoted to the physics of

the atmosphere, under the topics: astronomical phenomena, constitution of atmosphere, actinometry, atmospheric pressure, winds, cyclones and anti-cyclones, centers of high pressures, periodical winds, general circulation, atmospheric perturbations, hygrometry, electrical phenomena, climate, forecasting.

The treatment is thoroughly French; still, the author acknowledges his regret that the observations in different parts of France (where they appear to differ in time by as much as four to five hours) are not made simultaneously and frequently as are those in this country. The slowness in the development of meteorology, he considers, is due rather to a lack of skill exercised in making observations than to any lack in the volume of records.

Despite the variety of subjects treated, the book is without an index. D. A. K.

5. *Ostwald's Klassiker der Exacten Wissenschaften.* Leipzig, (Wilhelm Engelmann).—The following volumes have been recently added to this important collection of reprints of classical scientific memoirs:

No 140. Experimental-Untersuchungen über Elektricität; von Michael Faraday. XX bis XXIII Reihe. Herausgegeben von A. J. von Oettingen. Pp. 174.

No. 141. Über die Bestimmung einer Elliptischen Bahn aus drei vollständigen Beobachtungen; von J. F. Encke. Über die Bestimmung der Bahn eines Himmelskörpers aus drei Beobachtungen von P. A. Hansen. Herausgegeben; von J. Bauschinger. Pp. 162.

No. 142. Fünf Abhandlungen über absolute elektrische Strom- und Widerstandsmessung, von Wilhelm Meyer und Rudolph Kohlrausch. Herausgegeben; von Friedrich Kohlrausch. Pp. 116.

6. *Studies in Heterogenesis;* by H. Charlton Bastian. Pp. ix + 354 + xxxvii, 19 pls. containing 815 reproductions from microphotographs. London, 1904 (Williams & Norgate.)—Heterogenesis as defined by Dr. Bastian is "the production from the substance of organisms or their germs of alien forms of life." Numerous instances are given to show transformation of the contents of vegetal cells to amœbæ and monads, of algæ to diatoms. The egg of the Hydatina can be transformed into a ciliated infusorian! The processes by which Dr. Bastian arrives at his startling conclusions will hardly stand the test of modern scientific research.

Obituary.

M. F. A. Fouqué, the distinguished French geologist, petrographer and mineralogist, died at Paris on March 7, in his seventy-sixth year.

M. Henri Perrotin, the eminent French astronomer, Director of the Observatory at Nice, died early in March at the age of fifty-eight years.

Professor Fredrik Adam Smitt, the well known Swedish geologist, died on February 19, in his sixty-fifth year.

Dr. James Hyatt, one of the pioneers in science in this country, died at Bangall, N. Y. on February 27, in his eighty-seventh year.

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